AGRICULTURAL RESEARCH INSTITUTE

PUSA

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PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

1925

(INCORPORATED 1881.)

VOL. LIX.

EDITED BY

THE HONORARY SECRETARIES.

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VOLUME LIX.

NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{2}$ in. × $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

FORM OF BEQUEST.

I bequeath the sum of £   to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within   calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

PUBLICATIONS.

————o————

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.
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Royal Society of New South Wales.

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LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Journal. The numerals indicate the number of such contributions.

‡ Life Members

Elected.

1908		Abbott, George Henry, B.A., M B., Ch M., 185 Macquarie-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1918		Adam, George Hyslop, 'Lintrose,' Warren Road, Marrickville.
1904		Adams, William John, M. I. MECH. E., 175 Clarence-street
1898		Alexander, Frank Lee, William-street, Granville.
1905	P 3	Anderson, Charles, M.A., D.Sc Edin , Director of the Australian Museum, College-street. (President, 1924.) Vice-President.
1909	P 9	Andrews, Ernest C , B.A., F.G.S., Hon. Mem. Washington Academy of Sciences, Government Geologist, Department of Mines, Sydney (President, 1921.) Vice-President.
1915		Armit, Henry William, M R C.S. Eng, L.R.C.P. Lond., The Printing House, Seamer-street Glebe.
1919		Aurousseau, Marcel, B Sc., 9 Bannerman Street, Cremorne.

1923		Baccarini, Antonio, Doctor in Chemistry (Florence), 12 Roslyndale Avenue, Woollahra
1878		Backhouse, His Honour Judge A. P , M A., ' Melita,' Elizabeth Bay.
1924		Bailey, Victor Albert, M A , D.Phil, Assoc -Professor of Physics in the University of Sydney.
1921		Baker, Rev. Harold Napier, M.A. Syd., St. Thomas' Rectory, North Sydney.
1919		Baker, Henry Herbert, 15 Castlereagh-street.
1894	P 27	Baker, Richard Thomas, The Avenue, Cheltenham.
1894		‡Balsille, George, ' Lauderdale,' N.E. Valley, Dunedin, N.Z.
1919		Bardsley, John Ralph, "The Pines," Lea Avenue, Five Dock.
1908	P 1	Barling, John, L.S., ' St. Adrians,' Raglan-street, Mosman.
1918		Barr, Robert Hamilton, 37 Sussex-street.
1895	P 9	Barraclough, Sir Henry, K.B.E., B.E., M.M.E., M. INST. C E., M. I. MECH. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Dean of the Faculty of Engineering and Professor of Mechanical Engineering in the University of Sydney; p.r. ' Marmion,' Victoria-street, Lewisham.
1909	P 2	Benson, William Noel, D.Sc., Syd., B.A., Cantab., F.G.S., Professor of Geology in the University of Otago. Dunedin, N.Z.
1923		Berry, Frederick John, F.C.S , ' Roseneath,' 51 Reynolds-street, Neutral Bay.
1919		Bettley-Cooke, Hubert Vernon, 'The Hollies,' Minter-street, Canterbury.

Elected.

1923		Birks, George Frederick, c/o Potter & Birks, 15 Grosvenor-st.
1916		Birrell, Septimus, c/o Margarine Co., Edinburgh Road, Marrickville.
1920		Bishop, Eldred George, 16 Belmont-street, Mosman.
1915		Bishop, John 24 Bond-street.
1918		Bishop, Joseph Eldred, Killarney-street. Mosman.
1923		Blair, Kenneth John, 'Mimpi,' Parsley Road, Vaucluse.
1923	P 1	Blakely, William Faris, 'Myola' Florence-street, Hornsby.
1905		Blakemore, George Henry, Room 32, Third Floor, Commercial Bank Chambers, 273 George-street.
1888	‡	Blaxland, Walter, f.r c.s. *Eng.*, l r.c p. *Lond.*, 'Inglewood,' Florida Road, Palm Beach, Sydney.
1893		Blomfield, Charles E., b.c.e. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1917		Bond, Robert Henry, 'Elfindale,' Croydon Avenue, Croydon Pk.
1920	P 2	Booth, Edgar Harold, m.c., b.sc.. Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Bradfield, John Job Crew, D Sc Eng., M.E., M Inst. C.E, M. Inst. E. Aust. Chief Engineer, Metropolitan Railway Construction, Railway Department, Sydney.
1910	P 1	Bradley, Clement Henry Burton, m.b., Ch M., D.P.H., 'Nedra,' Little-street, Longueville; 211 Macquarie-street.
1876		Brady, Andrew John, l.k. and q.c.p. *Irel.*, l r c s. *Irel.*, 175 Macquarie-street, Sydney.
196		Bragg, James Wood, b.a., c/o Gibson, Battle &Co. Ltd., Kent-st.
1917		Breakwell, Ernest, b.a., b.sc. Headmaster Agricultural School, Yanco.
1891		Brennand, Henry J. W., b.a., m.b., Ch M. *Syd.*, 203 Macquarie-street; p.r 73 Milsons Road, Cremorne.
1923		Brereton, Ernest Le Gay, b sc.. Lecturer and Demonstrator in Chemistry in the University of Sydney.
1919	P 1	Briggs, George Henry, b.sc. Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Brough, Patrick, m.a., b.sc., b.sc, (Agr.) (Glasgow), Lecturer in Botany in the University of Sydney.
1923		Brown, Herbert, 'Sikoti,' Alexander-street, Collaroy Beach, Sydney.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Aberdour,' Daniel-street, Granville.
1913	P 8	Browne, William Rowan, D.sc., Assistant-Professor of Geology in the University of Sydney.
1925		Bryce, Ernest John, 'Wombin,' Nelson-road, Lindfield.
1921		Bull, James Towers, 48 Fort-street, Petersham.
1898		‡Burfitt, W. Fitzmaurice, b.a., m.b, Ch M. b.sc, *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1919	P 7	Burrows, George Joseph, b.sc.. Lecturer and Demonstrator in Chemistry in the University of Sydney; p.r. Watson-street, Neutral Bay.
1909		Calvert, Thomas Copley, assoc. m. inst. c.e., Department of Public Works, Sydney.
1904	P 25	Cambage, Richard Hind. c b.e. l.s., f.l.s., 49 Park Road, Burwood. (President 1912, 1923). *Hon Secretary.*
1925		Cameron, Lindsay Duncan, Hilly-street, Mortlake.
1907		Campbell, Alfred W., m.d., Ch M. *Edin.*, 183 Macquarie-street.

Elected		
1921		Campbell, John Honeyford, M.S.E., Deputy Master of the Royal Mint, Macquarie-street, Sydney.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliff Road, Edgecliff. Australia Chambers, George and Margaret-streets.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F F.A , *Scot.*, 4 Whaling Road, North Sydney.
1920		Carruthers, Sir Joseph Hector, K.C.M.G , M.I.C., M.A., *Syd.*, LL.D., *St. Andrews*, 'Highbury,' Waverley.
1908	P 3	Carslaw, Horatio S., M.A., Sc. D., Professor of Mathematics in the University of Sydney.
1913	P 3	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 2	Chapman, Henry G., M.D., B.S., Professor of Physiology in the University of Sydney. *Hon. Treasurer.*
1913	P 14	Cheel, Edwin, Curator National Herbarium, Botanic Gardens, Sydney.
1925		Clark, William E , ' Yacaaba.' Clement -street, Five Dock.
1909	P 20	Cleland, John Burton, M D., Ch M , Professor of Pathology in the University of Adelaide. (President 1917.)
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.* and *Edin* , 'Roseneath,' 8 Wallis street, Woollahra.
1896	P 4	Cook, W. E , M.C.E. *Melb.*, M. INST. C.E., Burroway-st., Neutral Bay.
1920		Cooke, Frederick, c/o Meggitt's Limited, 26 King-street.
1913	P 1	Cooke, William Ernest, M.A., F.R.A.S., Government Astronomer and Professor of Astronomy in the University of Sydney, The Observatory, Sydney.
1913	P 2	Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. Bannerman Crescent, Rosebery.
1882		Cornwell, Samuel, J.P., 'Capaneak,' Tyagarah, North Coast.
1919		Cotton, Frank Stanley, B.Sc , Chief Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 6	Cotton, Leo Arthur, M.A , D.Sc , Professor of Geology in the University of Sydney.
1919		Cowdery, Edward Henry. L.S., 6 Castlereagh-street, Sydney.
1892	P 1	Cowdery, George R , ASSOC. M. INST. C E., 154 Hay-street; p.r. 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P *Lond.*, 185 Macquarie-st.
1921		Cresswick, John Arthur, 101 Villiers-street, Rockdale.
1925		Curry, Harris Eric Marshall, 8 Lower Wycombe-street, Neutral Bay.
1912		Curtis, Louis Albert, L.S., F.I.S. (N.S.W.), V.D., No. 1 Mayfair Flats, Macleay-street, Darlinghurst.
1920		Daněs. Jiri Victor, Ph D. *Prague*, The University, Prague.
1890		Dare, Henry Harvey, M.E., M. INST. C.E., Commissioner, Water Conservation and Irrigation Commission, Union House, George-street.
1876	P 3	Darley, Cecil West, I.S.O., M. INST. C.E , 'Longheath,' Little Bookham, Surrey, England; Australian Club, Sydney.
1886		David, Sir Edgeworth, K.B.E., C.M.G., D.S.O , B.A., D.Sc, F.R.S., F.G.S., Wollaston Medallist, Emeritus Professor of Geology and Physical Geography in the University of Sydney; p.r. 'Coringah,' Sherbroke-road, Hornsby. (President 1895, 1910.)

Elected		
1922		Fleming, Edward Patrick, Under Secretary for Lands, Lands Department, Sydney.
1921		Fletcher, Joseph James, M.A., B.Sc., 'Ravenscourt,' Woolwich Road, Woolwich.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'The Astor,' Macquarie-street.
1920		Fortescue, Albert John, 'Benambra,' Loftus-street, Arncliffe.
1905		Foy, Mark, c/o Hydro Office, 138a Pitt-street, Sydney.
1904		Fraser, James, C.M.G., M. INST. C.E., Chief Commissioner for Railways, Bridge-street.
1907		Freeman, William, 'Ghyll Grange,' 50 Muston-st., Mosman.
1925		Friend, Norman Bartlett, 48 Pile-street, Dulwich Hill.
1918		Gallagher, James Laurence, M.A. *Syd.*, 'Akaroa,' Ellesmere Avenue, Hunter's Hill.
1921		Godfrey, Gordon Hay, M.A., B.Sc., Lecturer in Physics in the Technical College, Sydney; p.r. 262 Johnston-street, Annandale.
1897		Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.
1922	P 4	Grant, Robert, F C.S., Department of Public Health, 93 Macquarie-street.
1916		Green, Victor Herbert, 19 Bligh-street.
1922	P 1	Greig, William Arthur, Mines Department, Sydney.
1899	P 1	Greig-Smith, R., D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay. (President 1915.) *Hon. Secretary.*
1923		Gurney, William Butler, Government Entomologist, Department of Agriculture, Sydney.
1919		Grutzmacher, Frederick Lyle, F.C.S., Church of England Grammar School, North Sydney.
1891	P 16	‡Guthrie, Frederick B., F.I.C., 'Stanillo' Broughton-street, Moss Vale. (President 1903).
1919		Hack, Clement Alfred, Collins House, 360 Collins-street, Melbourne.
1880	P 5	Halligan, Gerald H., L.S., F.G.S., 'Hazeldene,' Burns Road, Wahroonga.
1912		Hallmann, E. F., B.Sc., 72 John-street, Petersham.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1919		Hambridge, Frank. 58 Pitt-street.
1916	P 1	Hamilton, Arthur Andrew, 'The Ferns,' 17 Thomas-st., Ashfield
1912		Hamilton, Alexander G., 'Tanandra,' Hercules-st., Chatswood.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; 'Glendowan,' Glenbrook, Blue Mountains. B.M.A. Building, 30 Elizabeth-st. (President 1899, 1908).
1909		Hammond, Walter L., B.Sc., High School, Bathurst.
1916		Hardy, Victor Lawson, 6 Dudley-street, Coogee.
1905	P 4	Harker, George, D.Sc., F.A.C.I., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.

Elected.		
1913	P 1	Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1919		Harrison, Launcelot, B.A. *Cantab.*, B.Sc, *Syd.*, Professor of Zoology in the University of Sydney.
1923		Harrison, Travis Henry, Lecturer in Entomology and Botany at the Hawkesbury Agricultural College, Richmond.
1918		Hassan, Alex. Richard Roby, c/o W. Angliss & Co. Ppty. Ltd., 64 West Smithfield, London, E C.
1919		Hay, Alexander, Coolangatta, N.S.W.
1916		Hay Dalrymple-, Richard T., L.S., Chief Commissioner of Forests, N. S. Wales; p.r. Goodchap Road, Chatswood.
1914		Hector, Alex. Burnet, c/o Hector Bros., Claremont, Marengo, *via* Young.
1891	P 4	Hedley, Charles, F.L.S., Muston-street, Mosman. (President, 1914.)
1916		Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.
1919		Henriques, Frederick Lester, 208 Clarence-street.
1919	P 2	Henry, Max, D S.O., B.V.Sc, M.R.C.V.S., 'Coram Cottage,' Essex-street, Epping.
1884	P 1	Henson, Joshua B., ASSOC. M. INST. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1918		Hindmarsh, Percival, M.A., B.Sc. (Agr.), Teachers' College, The University, Sydney; p.r. 'Lurnea,' Canberra Avenue, Greenwich.
1921	P 2	Hindmarsh, William Lloyd, B.V.Sc, M.R.C.V.S., D.V.H., District Veterinary Officer, Armidale.
1916		Hoggan, Henry James, A.M.I.M.E., A M.I.E. (Aust.). Manchester Unity Chambers, 160 Castlereagh-street; p r. 'Lincluden,' Frederick-street, Rockdale.
1924		Holme, Ernest Rudolph, O.B.E., M.A., Professor of English Language in the University of Sydney.
1901		Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.
1905	P 3	Hooper, George, F.T.C. *Syd* , Assistant Superintendent, Sydney Technical College; p.r. 'Nycumbene,' Nielson Park, Vaucluse.
1920		Hordern, Anthony, C.B.E., c/o Messrs. A. Hordern & Sons Ltd., Brickfield Hill.
1919		Horsfall, William Nichols, M.B., B.S. *Melb.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1919		Hoskins, Arthur Sidney, Eskroy Park, Bowenfels.
1919		Hoskins, Cecil Harold, Windarra, Bowenfels.
1919		Houston, Ralph Liddle, 'Noorong,' Cooper-street, Strathfield.
1906		Howle, Walter Cresswell, L.S.A. *Lond.*, 215 Macquarie-street
1913		Hudson, G. Inglis, J.P., F.C.S., 'Gudvangen,' Arden-st., Coogee.
1920		Hulle, Edward William, Commonwealth Bank of Australia.
1923	P 2	Hynes, Harold John, B.Sc, (Agr.), Walter and Eliza Hall Agricultural Research Fellow, Biological Branch, Department of Agriculture, Sydney.
1923		Ingram, William Wilson, M.C., M.D., Ch.B., The University, Sydney.

Elected		
1884		MacCormick, Sir Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street.
1887		MacCulloch, Stanhope H., M.B., Ch.M. *Edin.*, 26 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co., Ld., Hunter-street, Sydney.
1923		Mackay, Iven Giffard, C.M.G., D.S.O., B.A., Student Adviser and Secretary of Appointments Board, The University, Sydney.
1921		McDonald, Alexander Hugh Earle, Superintendent of Agriculture, Department of Agriculture, Sydney.
1908		McDonald, Robert, J.P., L.S., Pastoral Chambers, O'Connell-st; p.r. 'Lowlands,' William-street, Double Bay.
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.S. *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1919		McGeachie, Duncan, M.I.M.E., M.I.E. (Aust.), M.I.M M. (Aust.), 'Craig Royston,' Toronto, Lake Macquarie.
1906		McIntosh, Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., M. INST. C.E, Commissioner, Sydney Harbour Trust, Circular Quay.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. INST. C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.
1922		McLuckie, John, M.A., B.Sc. (*Glasgow*), D.Sc. (*Syd.*), Lecturer in Botany in the University of Sydney.
1901	P 1	McMaster, Colin J., L.S., 'Crona,' Keydon Avenue, Warrawee.
1916		McQuiggin, Harold G., M B , Ch.M , B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 'Berolyn,' Beaufort-street, Croydon.
1909		Madsen, John Percival Vissing, D.Sc, B.E., Professor of Electrical Engineering in the University of Sydney.
1924		Mance, Frederick Stapleton Under Secretary for Mines, Mines Department, Sydney; p r. 'Binbah,' Lucretia Avenue, Longueville.
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1920	P 1	Mann, Cecil William, Kent-street, Epping.
1920		Mann, James Elliott Furneaux, Barrister at Law, c/o Dr. W. F. Burfitt, 'Wyoming,' Macquarie-street
1908		Marshall, Frank, C.M.G., B.D.S., 151 Macquarie-street.
1914		Martin, A. H., Technical College, Sydney.
1912		Meldrum, Henry John, p r. 'Craig Roy,' Sydney Rd., Manly
1922		Mills, Arthur Edward, M.B., Ch M , Dean of the Faculty of Medicine, Professor of Medicine in the University of Sydney, 143 Macquarie-street.
1879		Moore, Frederick H., Union Club, Sydney.
1921		Morris, Albert, 74 Cornish-street, Railway Town, Broken Hill.
1922	P 8	Morrison, Frank Richard, Assistant Chemist, Technological Museum, Sydney; p.r. Brae-street, Waverley.
1924		Morrison, Malcolm, Department of Mines, Sydney.
1924		Mullens, Arnold Philip Redmyre Road, Strathfield.
1924		Mullens, Arthur Launcelot, c/o Mullens & Co., 115 Pitt-street.
1879		Mullins, John Lane, M.A. *Syd.*, M.L.C., 'Killountan,' Double Bay.
1915		Murphy, E. K., Dr. Ing., Chem. Eng., Lecturer in Chemistry, Technical College, Sydney.
1923	P 2	Murray, Jack Keith, B.A., B.Sc. (Agr.), Principal, Queensland Agricultural College, Gatton, Queensland.

Elected		
.893	P 4	Nangle, James, o.b.e., f.r.a.s., Superintendent of Technical Education, The Technical College, Sydney; p.r. ' St. Elmo,' Tupper-st., Marrickville. (President 1920.) *Vice-President*.
.917		Nash, Norman C., 'Ruanora,' Lucas Road, Burwood,
.924		Nickoll, Harvey, l.r.c.p., l.r.c.s., Barham, via Mudgee, N.S.W.
.891		‡Noble, Edward George, l.s., 8 Louisa Road, Balmain.
.920		Noble, Robert Jackson, m.sc., b.sc., (Agr), ph.d., 'Lyndon,' Carrington-street, Homebush.
1919		Oakden, Frank, c.e., 4 Bridge-street.
1903		‡Old, Richard, ' Waverton,' Bay Road, North Sydney.
1921		Olding, George Henry, 4 Bayswater Road, Drummoyne.
1913		Ollé, A. D., f.c.s., 'Kareema,' Charlotte-street, Ashfield.
1925		Ollé, Claude Henry, 30 Martin Place, Sydney.
1896		Onslow, Col. James William Macarthur, b.a., ll.b., 'Gilbulla,' Menangle.
1917		Ormsby, Irwin, 'Caleula,' Allison Road, Randwick.
1891		Osborn, A. F., assoc. m. inst. c.e., Water Supply Branch, Sydney, ' Uplands,' Meadow Bank, N.S.W.
1921	P 2	Osborne, George Davenport, b.sc., Lecturer and Demonstrator in Geology in the University of Sydney; p.r. 'Belle-Vue,' Kembla-st., Arncliffe.
1920		Paine, William Horace, State Abattoirs, Homebush Bay, N.S.W.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1921		Parkes, Varney, Royal Chambers, Castlereagh-street.
1920	P 3‡	Penfold, Arthur Ramon, f.c.s., Economic Chemist, Technological Museum, Harris-street, Ultimo.
1909	P 2	Pigot, Rev. Edward F., s.j., b.a., m.b. *Dub.*, Director of the Seismological Observatory, St. Ignatius'College, Riverview.
1879	P 8	Pittman, Edward F., assoc. r.s.m., l.s., 'The Oaks,' Park-street, South Yarra, Melbourne.
1881		Poate, Frederick, f r.a s., l.s., ' Clanfield,' 50 Penkivil-street, Bondi.
1919		Poate, Hugh Raymond Guy, m.b., ch m. *Syd.*, f.r.c.s. *Eng.*, l.r.c.p. *Lond.*, 225 Macquarie-street.
1917		Poole, William, m.e., (Civil, Min. and Met.) *Syd.*, m. inst. c.e., m.i.m.m., m.i.e. Aust., m.Am i m.e., m. Aust. i. m.m., l.s., 906 Culwulla Chambers, Castlereagh-street.
1896		Pope, Roland James, b.a., *Syd.*, m.d., c.m., f r.c.s., *Edin.*, 185 Macquarie-street.
1910		Potts, Henry William, f.l.s., f.c.s., c/o Lindley Walker & Co., Ltd., Mark Lane, Sussex-street, Sydney.
1921	P 2	Powell, Charles Wilfrid Roberts, a.i.c., c/o Colonial Sugar Refining Co., O'Connell-street.
1918		Powell, John, 170-2 Palmer-street.
1918		Priestley, Henry, m.d., ch. m., b.sc., Associate-Professor of Physiology in the University of Sydney.
1893		Purser, Cecil, b.a., m.b., ch.m. *Syd.*, 193 Macquarie-street.

Elected		
1912	P 2	Radcliff, Sidney, F.C.S., Department of Chemistry, The University of Sydney.
1922		Raggatt, Harold George, B.Sc., Lord-street, Roseville.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1909		Reid, David, ' Holmsdale,' Pymble.
1920		Richardson, John James. A.M.I.E.E. Lond., ' Kurrawyba,' Upper Spit Road, Mosman.
1921		Robertson, Frederick Arnold, Science Master, Sydney C. of E. Grammar School, North Sydney.
1924		Robertson, James R. M., M.D., C.M., F.R.G.S., F.G.S., 'Vanduara,' Ellamang Avenue, Kirribilli.
1884		Ross, Chisholm, M.D. Syd., M.B., C.M. Edin., 225 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1925		Roughley, Theodore Cleveland, Technological Museum, Sydney.
1897		Russell, Harry Ambrose, B.A., c/o Sly and Russell, 369 George-street; p.r. ' Mahuru,' Park Road, Bowral.
1907		Ryder, Charles Dudley, Box 1934 G.P.O. Sydney
1922		Sandy, Harold Arthur Montague, 326 George-street.
1917		Sawkins, Dansie T., M.A., ' Brymedura,' Kissing Point Road, Turramurra.
1920		Sawyer, Basil, B.E., 'Birri Birra,' The Crescent, Vaucluse.
1920		Scammell, Rupert Boswood, B.Sc. Syd., 18 Middle Head Road, Mosman.
1913		Scammell, W. J., Mem. Pharm. Soc. Grt. Brit., 18 Middle Head Road, Mosman.
1919		Sear, Walter George Lane, c/o J. Kitchen & Sons, Ingles-st., Port Melbourne.
1923	P 1	Seddon, Herbert Robert D.V.Sc., Director, Veterinary Research Station, Glenfield.
1921		Sellers, Alfred Edward Oswald, M.I.M.E., M.A.I.E., 'Strathmere,' Bellambi.
1918		Sevier, Harry Brown, c/o Lewis Berger and Sons (Aust.) Ltd., Cathcart House, Castlereagh-street.
1924		Shelton, James Peel, M.Sc., B.Sc., Agr., Department of Agriculture, Sydney.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1910		Simpson, William Walker, 'Strathford,' Lord-street, Roseville
1916		Smith, Stephen Henry, Under Secretary and Director of Education, Department of Education, Sydney.
1922	P 1	Smith, Thomas Hodge, Australian Museum, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc, Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, 'Araboonoo,' Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, Daily Telegraph Building, King-st.
1916		Stephen, Alfred Ernest, F.C.S., 801 Culwulla Chambers, 67 Castlereagh-street, Sydney.
1921		Stephen, Henry Montague, B.A., LL.B., 167 Phillip-street
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 13 Dover Road, Rose Bay.

Elected		
1920	P 1	Stephens, John Gower, M.B., Royal Prince Alfred Hospital, Camperdown.
1913		Stewart, Alex. Hay, B.E., 165 Wardell Road, Dulwich Hill.
1900		Stewart, J Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; 'Berelle,' Homebush Road, Strathfield.
1909		Stokes, Edward Sutherland, M.B. Syd., F.R.C.P. Irel., Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1916	P 1	Stone, W. G., Assistant Analyst, Department of Mines, Sydney.
1919		Stroud, Sydney Hartnett, F.I.C., c/o Elliott Bros., Balmain; p r. Fifth-street, South Ashfield.
1918		Sullivan, Herbert Jay, c/o Lewis Berger and Sons (Aust.) Ltd., Rhodes.
1920		Sulman, Sir John, Kt., Warrung-st., McMahon's Point, North Sydney.
1918		Sundstrom, Carl Gustaf, c/o Federal Match Co., Park Road, Alexandria.
1901	P 11	Sussmilch, C. A., F.G.S., Principal of the Technical College, Newcastle, N.S.W. (President 1922.) Vice-President.
1919		‡Sutherland, George Fife, A.R.C.Sc., Lond., Assistant-Professor in Mechanical Engineering, in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M D., D.P.H. Melb., B.Sc Oxon., 'Lynton,' Kent Road, Rose Bay.
1919		Swain, Herbert John, B.A. Cantab., B.Sc, B.E. Syd., Lecturer in Mechanical Engineering, Technical College, Sydney.
1925		Taylor, George Augustine, F.R.A.S., F.R.G.S., 20 Loftus-street, Sydney.
1915	P 2	Taylor, Harold B., D.Sc., Kenneth-street, Longueville.
1893		‡Taylor, James, B.Sc, A.R.S.M. 'Cartref,' Brierly-st., Mosman.
1921	P 2	Taylor, John Kingsley, Hawkesbury Agricultural College, Richmond; p.r. 16 Ferrier-street, Rockdale.
1905		Taylor, John M., M.A., LL.B. Syd., 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1921	P 4	Taylor, Thomas Griffith, B.A., D.Sc., B.E., Associate-Professor of Geography in the University of Sydney.
1920		Tebbutt, Arthur Hamilton, B.A , M.B., D.P.H., 185 Macquarie-st.
1899		Teece, R., F.I.A., F.F A., Wolseley Road, Point Piper.
1923		Thomas, David, B.E., M.I.M.M , F G.S., 15 Clifton Avenue, Burwood.
1878		Thomas, F. J., 'Lovat,' Nelson-street, Woollahra.
1919		Thomas, John, L.S., Chief Mining Surveyor, Mines Department Sydney; p.r. 'Remeura,' Pine and Harrow Roads, Auburn.
1924		Thompson, Herbert William, 'Marathon,' Francis-st ,Randwick
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-st.
1919		Thorne, Harold Henry, B.A. Cantab., B.Sc. Syd., Lecturer in Mathematics in the University of Sydney; p.r. Rutledge-st., Eastwood.
1916		Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.E.S., Biological Branch, Cawthron Institute, Nelson, New Zealand.
1923		Timcke, Edward Waldemar, Meteorologist, Weather Bureau, Sydney.

Elected		
1923		Tindale, Harold, Works Engineer, c/o Australian Gas-Light Co., Mortlake.
1923		Toppin, Richmond Douglas, A.I.C., Parke Davis & Co., Rosebery.
1879		Trebeck, P. C., 'Banavie,' Bowral.
1900		Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st.
1925		Tye, Cyrus Willmott Oberon, Under Secretary for Public Works, Public Works Dept., Sydney.
1916		Valder, George, J.P., Under Secretary and Director, Department of Agriculture, Sydney; p.r. No. 3 Milner-street, Mosman.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S. Guild; Challis House, Martin Place.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George B., 78 Pitt-street.
1903	P 5	Vonwiller, Oscar U., B.Sc, Professor of Physics in the University of Sydney.
1924		Wade, Rev. Robert Thompson, M.A., Headfort School, Killara.
1919		Waley, Robert George Kinloch, 63 Pitt-street.
1910		Walker, Charles, 'Lynwood,' Terry Road, Ryde.
1910		Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.
1879		Walker, H. O., 'Moora,' Crown-street, Parramatta.
1919	P 1	Walkom, Arthur Bache, D.Sc, Macleay House, 16 College-st.
1903		Walsh, Fred., J.P, Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn Comm. of Aust.; Memb. Patent Attorney Exam. Board Aust; George and Wynyard-streets; p.r 'Walsholme,' Centennial Park, Syd.
1901		Walton, R. H., F C.S., 'Flinders,' Martin's Avenue, Bondi.
1918		Ward, Edward Naunton, Curator of the Botanic Gardens, Syd.
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.S. Syd., Lecturer and Demonstrator in Physiology in the University of Sydney.
1922		Wark, Blair Anderson, V.C., D.S.O., M.I.Q.C., c/o Thompson and Wark, T. & G Building, Elizabeth-street; p.r. 'Braeside,' Zeta-street, Lane Cove, Sydney.
1921		‡Waterhouse, G. Athol, D.Sc, B.E., F.E.S., Royal Mint, Macquarie-street.
1924		Waterhouse, Leslie Vickery, B E. Syd , 58 Pitt-street.
1919		Waterhouse, Lionel Lawry, B.E. Syd , Lecturer and Demonstrator in Geology in the University of Sydney.
1919	P 2	Waterhouse, Walter L., M.C.,B.Sc. (Agr.), 'Hazelsmere,' Chelmsford Avenue, Roseville.
1919		Watkin-Brown, Willie Thomas, F.R.M.S., 33 Renwick-street, Redfern.
1876		Watkins, John Leo, B.A. Cantab., M.A. Syd., University Club, Castlereagh-street
1910		Watson, James Frederick, M.B., Ch M., 'Midhurst,' Woollahra.
1911		Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney. President.

Elected		
1920	P 14	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum.
1907	P 1	Welch, William, F.R.G s., 'Roto-iti,' Boyle-street, Mosman.
1920	P 1	Wellish, Edward Montague, M.A., Associate-Professor in Mathematics in the University of Sydney.
1921		Wenholz, Harold, Department of Agriculture, Sydney.
1881		‡Wesley, W. H., London.
1922		Whibley, Harry Clement, 39 Moore-street, Leichhardt.
1909	P 3	White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's College.
1918		White, Edmond Aunger, M.A.I.M.E., c/o Electrolytic Refining and Smelting Co. of Australia Ltd., Port Kembla, N.S.W.
1892		White, Harold Pogson, F.C s., Assistant Assayer and Analyst, Department of Mines; p.r.'Quantox,' Park Road, Auburn.
1923		Whitehouse, Frank, B.V.Sc, (Syd.) 'Dane Bank,' Albyn Road, Strathfield.
1921		Willan, Thomas Lindsay, B Sc, Alluvial Tin (Malaya), Ltd., Rawang, Selangor, Federated Malay States.
1920		Williams, Harry, A.I.C., c/o Whiddon Bros.' Rosebery Lanolines Pty. Ltd , Arlington Mills, Botany.
1924		Williams, William John, 5 Effingham-street, Mosman.
1917		Willington, William Thos., O.B.E., King-street, Arncliffe.
1923		Wilson, Stanley Eric, 'Chatham,' James-street, Manly.
1891		Wood, Percy Moore, L.R.C.P. Lond , M.R.C.S. Eng., 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 9	Woolnough, Walter George, D.Sc., F G.S., 'Callabonna,' Florence-street , Killara.
1916		Wright, George, c/o Farmer & Company, Pitt-street.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, 184 Sussex-street.

HONORARY MEMBERS.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1918		Chilton, Charles, M.A., D.Sc, M B.,C.M., etc., Professor of Biology, Canterbury College, Christchurch, N.Z.
1914		Hill, James P., D.Sc, F.R.S., Professor of Zoology, University College, London.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. ENG., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1908	P 57	*Liversidge, Archibald, M.A., LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney, ' Fieldhead,' George Road, Coombe Warren, Kingston, Surrey, England. (President 1889, 1900.)
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia, ' Bon Accord,' 2 Charles-street, South Perth, W.A.

* Retains the rights of ordinary membership. Elected 1872.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.,
Vice-President from 1866 to 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia.   The prefix * indicates the decease of the recipient.

Awarded
1878   *Professor Sir Richard Owen. K.C.B., F.R.S.
1879   *George Bentham, C.M.G., F.R.S.
1880   *Professor Thos. Huxley, F.R.S.
1881   *Professor F. M'Coy, F.R.S., F.G.S.
1882   *Professor James Dwight Dana, LL.D.
1883   *Baron Ferdinand von Mueller, K.C.M.G , M.D., Ph D., F.R.S., F.L.S.
1884   *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885   *Sir Joseph Dalton Hooker, O.M., G.C.S.I.,C.B., M.D.,D.C.L., LL.D.,F.R.S.
1886   *Professor L. G. De Koninck, M.D.
1887   *Sir James Hector, K.C.M.G., M.D , F.R.S.
1888   *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889   *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890   *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891   *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892   Sir William Turner Thiselton Dyer, K.C.M.G.,C.I.E.,M.A., LL.D., Sc. D.,
           F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1893   *Professor Ralph Tate, F.L.S., F.G.S.
1895   *Robert Logan Jack, LL.D., F.G S., F.R.G.S.
1895   *Robert Etheridge, Jnr.
1896   *The Hon. Augustus Charles Gregory, C.M.G., F R.G.S.
1900   *Sir John Murray, K.C.B., LL.D., Sc. D., F.R.S.
1901   *Edward John Eyre.
1902   *F. Manson Bailey, C.M.G.. F L S.
1903   *Alfred William Howitt, D.Sc , F.G.S.
1907   Walter Howchin, F.G.S., University of Adelaide.
1909   Dr. Walter E. Roth, B.A , Pomeroon River, British Guiana, South
           America.
1912   *W. H. Twelvetrees, F.G S.
1914   A. Smith Woodward, LL.D., F.R.S , Keeper of Geology, British
           Museum (Natural History) London.
1915   *Professor W. A. Haswell, M A., D.Sc., F.R.S.
1917   Professor Sir Edgeworth David, K.B.E., C.M.G., D S.O., B.A., D.Sc ,
           F.R.S., F.G S., The University, Sydney.
1918   Leonard Rodway, c M.G., Honorary Government Botanist, Hobart,
           Tasmania.
1920   *Joseph Edmund Carne, F.G.S.
1921   Joseph James Fletcher, M.A., B.Sc , 'Ravenscóurt,' Woolwich.
1922   Richard Thomas Baker, The Avenue, Cheltenham.
1923   Sir W. Baldwin Spencer, K.C.M.G., M.A., D.Sc F.R.S., National
           Museum, Melbourne.
1924   *Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., J.P.
1925   Hedley, Charles, F.L S., Muston-street, Mosman.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882   John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882   Andrew Ross, M.D , Molong. for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884   W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

1886   S. H. Cox, F.G.S., F C S., Sydney, for paper entitled 'The Tin deposits of New South Wales.'

1887   Jonathan Seaver, F.G S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888   Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia '

1889   Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889   Rev. John Mathew, M A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891   Rev. J. Milne Curran, F.G.S , Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892   Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894   J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894   R. H Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895   C. J. Martin, D.Sc, M B , F R S , Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (Pseudechis porphyriacus).'

1896   Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By C. ANDERSON, M.A., D.Sc.

Delivered to the Royal Society of New South Wales on May 6, 1925.

At this, the 452nd General Meeting of the Royal Society of New South Wales, I have the satisfaction of reporting that steady progress in the work of our Society has been maintained during the preceding year. Twenty-two papers were read and discussed at the monthly meeting and four Popular Science Lectures were delivered.

Several of our members have been honoured in the last twelve months. Mr. John Sulman has been made Knight Bachelor, and we have to congratulate Professor Sir Edgeworth David on having had conferred upon him by the Geological Society of America, the Honorary Degree of Correspondent, for his eminent services in the cause of geology; also on his election as Honorary Member of the Geological Society of Belgium, and Foreign Member of the Royal Bohemian Academy of Science, Prague. Professor J. Kenner and Dr. R. J. Tillyard have been elected Fellows of the Royal Society of London.

On the 27th May, 1924, the Society had the honour of welcoming Dr. V. Stefansson, the celebrated Arctic explorer, on his arrival in Sydney.

During the year twenty-three new members have joined the Society and eight resignations have been received. We have lost eleven Ordinary Members and one Honorary Member by death, and the membership now stands at 379, a slight increase over that of last year.

OBITUARY.

It is with deep regret that I announce the deaths of W. Botting Hemsley, W. E. Abbott, H. E. Barff, W. H. Baxter, W. P. Faithfull, T. F. Furber, W. A. Haswell, T. H. Houghton, J. I. Hunter, H. E. Kater, H. G. Smith and A. G. Stoddart.

WILLIAM BOTTING HEMSLEY, who was elected as Honorary Member in 1911 and died on 7th October, 1924, in his eighty-first year, was born at East Hoathly, Sussex, England. His family had long been connected with the study and practice of horticulture, and young Hemsley commenced his life-long association with the subject of botany as a gardener in his father's establishment. In 1860, at the age of seventeen, he entered Kew as a gardener, but was soon transferred to the Herbarium, where, among other duties, he assisted Bentham in the preparation of the "Flora Australiensis." He suffered at intervals from indifferent health, and in 1867 he was obliged, on that account, to relinquish his position at Kew, though he was still able to continue his botanical work. In 1874 he returned to Kew as an independent worker, and, for the following nine years, he was employed mainly in describing the phanerogams collected by the "Challenger"; his report was published in 1885, and his reputation as an authority on insular floras was established. In 1883 he was again made a permanent member of the Kew staff, and in 1899 he became Keeper of the Herbarium and Library, an office which he held until his retirement in 1908. He was elected a Fellow of the Royal Society of London in 1889. Hemsley's contributions to botanical science, which were numerous and important, were chiefly of a systematic nature. His work on the flora of China occupies three volumes of the Linnean Society's Journal, while his botanical contributions to the "Biologia Centrali-Ameri-

-cana" ran into five volumes. He was also associated with the elaboration of the plants collected by the Afghan Boundary Commission, and in the production of a valuable "Flora of High Asia." He, with other members of the Kew staff, shared in the preparation of the Flora of Tropical Africa. We, in Australia, owe much to the scholarship and wide botanical knowledge of our late Honorary Member.

WILLIAM EDWARD ABBOTT, of Wingen, New South Wales, who joined the Society in 1877, died on 14th April, 1924. A son of John Kingsmill Abbott, he was born at Muswellbrook in April, 1844. Since 1860 he was engaged in pastoral pursuits on the Upper Hunter, but in the intervals of a busy life he found time to devote himself to scientific and literary work, and contributed several papers to our Journal, dealing mainly with water supply and other aspects of the land industry. In 1884 he was awarded the bronze medal of the Society for his paper "Water Supply in the Interior of New South Wales." He was the author of a valuable and interesting book, "Mount Wingen and the Wingen Coal Measures."

H. E. BARFF, who had been a member since 1896, died on 2nd May, 1925. His death removed one who has played an important part in the history of the University of Sydney, of which he was Registrar for many years, and Warden since 1914 until his retirement last year. He was a son of the Rev. John Barff, who laboured as a missionary in Tahiti. Born 67 years ago, he entered the University of Sydney as a student in 1873, and graduated in Arts three years later. In 1878 he became Lecturer in Mathematics, and in 1880 he was appointed Acting Registrar, and in 1882 Registrar. Mr. Barff devoted his life to the welfare of the University and earned for himself a high reputation as an administrator by reason of his

tact, his sound judgment, and his wide knowledge. During Mr. Barff's association with the University that institution has grown from a small academy with four professors and about 50 students to its present proud position as one of the most important universities in the Empire with a staff of nearly 250, and more than 3,000 students. Mr. Barff was regarded as the most experienced academic authority in Australia, and for his eminent services his name was included in the 1923 New Year's honours list, when he was made C.M.G.

WILLIAM HOWE BAXTER, late Chief Surveyor of the Existing Lines Branch, Railway Department of New South Wales, died on 3rd March, 1925, at the age of seventy. He was born at Barton-on-Humber, England, and was a son of the Rev. T. N. Baxter. Coming to Australia in 1877, he became connected with the Railway Department of this State, and remained in that service for over forty-four years, during which time he conducted many important surveys. One of his most notable achievements was the alignment of the tunnel between Long Nose Point and Greenwich on the Parramatta River, a work involving great skill and accuracy and no small degree of persever-ance. The success which he achieved in this work may be gauged by the fact that when the two sections of the tunnel were "joined," the alignment was found to be correct within the fraction of an inch. Mr. Baxter endeared himself to all with whom he came in contact by his unfailing courtesy and kindly disposition. He had been a member of the Society since 1894.

WILLIAM PERCY FAITHFULL, who died 22nd November, 1924, at the advanced age of eighty, joined the Society in 1904. He was born at Springfield, near Goulburn, and educated at King's School, Parramatta, whence he pro-ceeded to the University of Sydney. After graduating in

Arts, he read Law, and was admitted to the Bar and practised for some time, but, later, he took up sugar-planting in Queensland. He took a great interest in hospital matters, and was for many years closely associated with the Royal Alexandra Hospital for Children.

THOMAS FREDERICK FURBER, who died 7th October, 1924, was one of the most outstanding figures in Australasia in connection with the higher branches of surveying. He was born in England in 1855, and entered the Survey Branch of the Lands Department, New South Wales, in 1869. Very early in his career he displayed wonderful mathematical ability, and became a member of the Licensed Surveyors' Examination Board when he was but twenty-six years of age. He was employed in the Trigonometrical Branch, where he became chief computer in 1890, and in 1904 he was appointed Metropolitan District Surveyor and Director of Trigonometrical Surveys, which position he filled until his retirement in 1914. He was a Fellow of the Royal Astronomical Society, and for many years he lectured on Geodesy and Astronomy in the University of Sydney. In December, 1882, he went to Lord Howe Island for the purpose of making observations in connection with the transit of Venus. He was one of the founders of the Institution of Surveyors of New South Wales, of which he was Honorary Secretary for many years and four times President. His interest in scientific matters was keen, and he was a member of the Society for forty-three years. Mr. Furber was energetic and conscientious in the discharge of his public duties, devoted to his profession, and full of the highest ideals.

WILLIAM AITCHESON HASWELL, who died 24th January, 1925, was one of the foremost of the world's zoologists. He was born at Edinburgh, Scotland, on 5th August, 1854, and was educated at the University of Edinburgh, where

He graduated as Master of Arts and Bachelor of Science, after a brilliant career as a student. He studied medicine for some time, but abandoned his intention of entering that profession and resolved to devote himself to natural history. He came to Australia in 1878, partly for health reasons, and in December, 1879, he was appointed Curator of the Queensland Museum. In 1882 he became Demonstrator in Zoology, Comparative Anatomy and Histology in the University of Sydney, and, later, Lecturer in the same subjects. In 1890 he was elected to the newly created Chair of Biology, which he held until 1914, when his title was changed to Professor of Zoology on the appointment of a Professor of Botany. In 1917 he retired with the title of Professor *emeritus*, though he continued his scientific work in the quietude of his private laboratory at Point Piper almost up to the day of his death. He was deeply interested in museum work and was a Trustee of the Australian Museum from February, 1891, to December, 1923. He was elected a Fellow of the Royal Society of London in 1897.

Professor Haswell's contributions to zoological science covered a wide field. His interest was chiefly in the invertebrate groups, particularly the Crustacea and the Annelida, but he also made important researches in the vertebrate phylum, investigating the paired limbs of *Ceratodus*, the myology of marsupials and other subjects. He made a special study of the Temnocephaloidea, a group of flat worms parasitic on crayfishes, and was recognised as the leading authority on that group. His last paper, which appeared in the Proceedings of the Linnean Society of New South Wales for 1924, was the first part of a revision of the Temnocephaloidea. Haswell was perhaps best known as joint author with the late Professor T. Jeffrey Parker of the celebrated "Text-book of Zoology,"

familiarly known as "Parker and Haswell," which has maintained its place as a standard work for over a quarter of a century. The first edition appeared in 1898, and, by the charm of its style and the judicious arrangement of its contents, it quickly established itself as the leading text-book in all English-speaking countries. Subsequent editions appeared in 1910 and 1921, and these were prepared entirely by Haswell, his collaborator having died shortly after the appearance of the original edition. Professor Haswell was of a retiring disposition, extremely modest and unassuming in his manner, but to those who were privileged to know him well, he disclosed a kindliness and consideration for others such as one rarely encounters. He was full, too, of a quiet humour, and, as he had a retentive memory and a well-stored mind, his conversation was both instructive and entertaining. He joined the Society in 1884 shortly after his arrival in Sydney, and in 1915 he was awarded the Clarke Memorial Medal for his contributions to the natural history of Australia.

THOMAS HARRY HOUGHTON, elected a member in 1891, died 26th September, 1924. He was born at Dudley, England, in January, 1857, and arrived in Australia in 1890, when he installed the pumping plant at the Crown Street Waterworks, Sydney. In 1891, on the completion of this work, he entered into private practice in Sydney and quickly won for himself a high position as a professional engineer. During his career he was associated with the carrying out of many important public and private works, and his services were frequently in demand for purposes of report, valuation, and arbitration. He took a leading part in all matters concerning his profession, and his advice and co-operation were often sought by various scientific and technical bodies, of which he was an active member. He was a member of the Council when

his death occurred, having served in that capacity since 1906, and he occupied the Presidential Chair in 1916. On the occasion of his death the following resolution was passed by his colleagues on the Council of the Royal Society:

> That the members of this Council desire to place on record their very high appreciation of the services rendered to the Society by their late colleague, Mr. T. H. Houghton, M.Inst.C.E., a past President, who was ever ready to place his professional knowledge and experience as a supervisor at the disposal of the Council in all matters relating to structural alterations to the Society's House and has done this on many occasions to the Society's great advantage.

He was a man of a genial and obliging disposition, and his wise counsel and ready help were always at the service of the Society, which by his death has suffered a grievous loss.

JOHN IRVINE HUNTER, who died suddenly in London on 10th December, 1924, at the early age of twenty-six, was recognised as one of the most brilliant anatomists of our time, for in spite of his youth he had made contributions of far-reaching importance to anatomical and surgical science. The others whose loss we mourn had mostly reached the allotted span, and their life of achievement was behind them, but Professor Hunter was on the very threshold of life, and his death is no less than a calamity. Had he lived and fulfilled his early promise, he would undoubtedly have ranked very high among the scientific men of his generation. It is impossible to estimate the loss that Australia and the world have sustained by the untimely death of John Irvine Hunter. He was born at Bendigo, and received his early education at the Albury District School. In January, 1913, he became a pupil at Fort Street Boys High School, and two years later he entered the Medical School of Sydney University. As a

student he had an exceptionally brilliant career, winning practically every prize and scholarship for which he was eligible, and he graduated in 1920 with first-class honours and the University Medal. For two years prior to graduation he had acted as Prosector and Demonstrator in Anatomy, and he so impressed Professor J. T. Wilson, who then occupied the Chair of Anatomy, that he was appointed Associate-Professor of Anatomy almost immediately after graduation, being then only twenty-one years of age. After lecturing for a term he was granted two years' leave of absence to enable him to study methods of teaching and research in anatomy, and spent the greater part of the time working in association with Professor Grafton Elliot Smith at University College, London. One of the important pieces of work accomplished by these two brilliant graduates of Sydney University was a new reconstruction of the famous Piltdown skull, demonstrating that the jaw which had been associated with the skull, and which some anatomists had supposed to be that of an ape, was really human. Returning to Sydney, Hunter was immediately appointed to the Chair of Anatomy in succession to Professor J. T. Wilson, a signal achievement for so young a man. As a lecturer and teacher, Hunter was surpassed by few, as will be admitted by those of you who heard him lecture in this Hall on 17th July, 1924, on "Experimental Observations on the Organisation of the Human Nervous System." He will be remembered best for the wonderful results obtained in collaboration with Dr. N. P. Royle in the treatment of paralysis. As the outcome of a series of carefully planned experiments on animals, the two young investigators made the important discovery that the sympathetic nerves have an importance which had not previously been suspected. The ordinary nerve fibres transmit impulses which produce movements at will, and, as the outcome of these epoch-

making researches, we now know that the sympathetic nerves have the function of "locking" the limb in the new position. The great discovery of Hunter and Royle was that, if the sympathetic nerve responsible for the rigidity of a limb affected by paralysis be severed, the limb recovers its freedom of movement and regains its normal healthy condition. This is one of the most important advances in medical science that has been made for many years, and it is yet too early to assess its value as a means of lessening the sum of human suffering.

In June, 1924, Professor Hunter and Dr. Royle were invited to deliver the Dr. John B. Murphy oration at the Clinical Congress held in New York in October last. This is the highest honour in the gift of the College of Surgeons of New York, and the invitation was justly regarded as a high compliment to the two young scientists and to the University of Sydney. Before returning to Sydney, Professor Hunter visited London, and was preparing to deliver a series of free public lectures at University College, on "The Anatomy and Physiology of the Sympathetic Innervation of the Striated Muscle," when, on Saturday, 6th December, he was stricken with typhoid, and died on the following Wednesday. Hunter joined our Society in 1923, and many of you no doubt knew him well and admired his unselfish character, his simplicity and his modesty. He was unspoiled by his meteoric rise to fame, and still retained the boyish exuberance and enthusiasm which marked his undergraduate days. He was not only a man to admire but one to love. "Fame has only the span of a day, they say, but to live in the hearts of the people—that is worth something."

HENRY EDWARD KATER, who became a member in 1883, died on 23rd September, 1924, at the age of eighty-three. He was born at Bungarribee, near Penrith. His father,

H. H. Kater, was one of the early pioneers, and his grand-
father, Captain Henry Kater, was a distinguished scien-
tist, to whom were awarded a Royal Medal and the Copley
Medal of the Royal Society of London; he was the
inventor of the prismatic compass still used by surveyors.
Mr. H. E. Kater had many interests, but his name is
inseparably associated with the sheep-breeding industry,
and the merinos of H. E. Kater and son are celebrated
throughout the Commonwealth. He was closely associated
with the Royal Prince Alfred Hospital, which owes much
to his sound counsel, sympathetic interest and generous
contributions. He endowed the H. E. Kater Ward and
presented the first X-ray apparatus possessed by the
Hospital. He was a man of great kindliness of heart and
public spirit, which found expression in many directions.
He became a member of the Legislative Council in 1889,
when Sir George Dibbs was Premier, and his contribu-
tions to the debates in the Council, especially on matters
relating to land, local government and such questions,
were very valuable.

HENRY GEORGE SMITH, who died on 19th September,
1924, at the age of seventy-two, had been a member of
the Society since 1893. He was born at Littlebourne,
Kent, England, and came to Australia in 1883 on account
of his health. Soon after his arrival he obtained an
appointment in the Technological Museum, Sydney, then
housed in the Domain. In 1891 he became laboratory
assistant, and in 1899 Assistant-Curator and Economic
Chemist. He devoted himself whole-heartedly to his great
life work, the investigations of the essential oils and other
chemical products of the Australian flora. His published
papers reached a total of over a hundred, several of them
being written in collaboration with his botanical colleague,
Mr. R. T. Baker, for many years Curator of the Techno-

logical Museum. The most important outcome of this happy association of botanist and chemist was the comprehensive work, "A Research on the Eucalypts and their Essential Oils," first issued in 1902. Another important joint work, appearing in 1910, was "A Research on the Pines of Australia," the most complete treatise yet published on the morphology and chemical characters of our conifers. After retiring from his position at the Technological Museum he continued his researches in the organic chemistry department of the University of Sydney in association with Professor John Read.

The work of H. G. Smith was characterised by originality and accuracy, and he always had a due appreciation of the economic importance of his researches, which have contributed materially to the success of several industries. He was a member of the Council of the Royal Society of New South Wales for twenty-four years and was President in 1913. He was an original member of the Australian National Research Council, and in 1923 was President of the Chemistry Section of the Australasian Association for the Advancement of Science. He was an Honorary Member of several British and American scientific bodies, and was awarded the Syme Prize by the University of Melbourne in recognition of his eminent services to chemical science. On 24th September, 1924, the Council of this Society passed the following resolution:

> That this Council of the Royal Society of New South Wales record in its Minutes its high appreciation of the services of its late member, Henry George Smith, in the promotion of the interests of the Society, in the advancement of knowledge in the domain of chemistry, and in extending the avenues for the development of the resources of the State of New South Wales and of the Commonwealth of Australia.

His character was marked by simplicity and sincerity, and his unflagging zeal in his chosen field of work was an inspiration to all his associates.

ALFRED GEORGE STODDART, who died on 26th August, 1924, had been a member since 1903. He was born at London in 1854, and came to Australia forty-six years ago. He was for thirty years Rector of St. Matthews' Church of England, Manly, and had previously served at Kelso, Redfern, Milton, and Sutton Forest. He was clerical Secretary of the Diocesan Synod from 1887 to 1910. During the war Mr. Stoddart served as a chaplain with the Australian Imperial Forces in Egypt and England, and was extremely popular with officers and men.

SCIENTIFIC ACTIVITIES.

The Australasian Association for the Advancement of Science held a very successful meeting at Adelaide in August, 1924. Many important papers were read and several fruitful and stimulating discussions took place. The next meeting of the Association will be held at Perth, Western Australia, in August, 1926, and it is hoped that a large number of visitors from the eastern States will take advantage of the travelling concessions which are now being arranged for.

Matters are now in train for the holding of the next Pan-Pacific Science Congress in Japan, about October, 1926. It is hoped that arrangements can be made whereby a vessel will be available by which those who take part in the Perth meeting of the Australasian Association will be able to travel from Perth, direct to Japan to attend the Pan-Pacific Congress.

Among the important matters which the Australian National Research Council has had in hand during the year has been the necessary work in connection with the proposed Chair of Anthropology in Australia. This proposal is the outcome of a resolution passed by the Pan-Pacific Science Congress in 1923, and, after interviews

with the Prime Minister, at which Sir David Orme Masson, President of the Council, was supported by the Australasian Association for the Advancement of Science and the various State Universities, the Commonwealth Government undertook to provide an annual sum of £1000 if the States would subscribe the necessary balance, and it was arranged that the Chair should be founded at the University of Sydney.

Under the auspices of the Research Council, in co-operation with the Australian Chemical Institute, a national Committee in connection with the Union of Pure and Applied Chemistry has been formed, and it is hoped that this will be of distinct benefit in connection with research work.

The Research Council is forming a committee to investigate questions of temperature, salinity, etc., of the Pacific Ocean, and Dr. T. Wayland Vaughan, of the Scripps Institute, La Jolla, California, has been appointed Chairman, with Professor H. C. Richards, of the University of Queensland, in charge of Australian operations.

During the year the first biological survey station for the study of the fauna and flora of Australia has been formed. The National Park Trust has handed over to the Royal Zoological Society of New South Wales a cottage at Gundamaian Bay, which will be the headquarters of the zoologists, and also a cabin at Palm Creek, near Waterfall, where the members of the Ornithological Section will study the bird life. As the fauna and flora of the National Park are still more or less in their original undisturbed condition, we may expect interesting and valuable results from this biological survey station, and all nature lovers will applaud the public spirit of the Trustees of the National Park, and of the Chairman, Mr. Frank Farnell, for this generous gift.

THE AUSTRALIAN FAUNA.

For the second part of my address I have chosen the subject of the Australian fauna. I fear that I am not competent to deal with that theme in any but a very general manner, as I cannot claim to be an expert in any branch of zoology. I feel, however, that the subject with which I am most familiar, namely, mineralogy (and especially the crystallographic properties of minerals) is so specialized that it would not appeal to the members of our Society. On the other hand there are so many interesting problems associated with the study of our fauna that, it seemed to me, it might well form the subject of my address.

It has often been said that the Australian fauna is one of the most interesting and important in the world. The reason for this is to be found mainly in the fact that Australia was severed from other land masses at a fairly distant date geologically speaking, and, when this happened, it contained a fauna which was more or less representative of the animal life of the time. Removed from competition with more highly endowed animals which subsequently evolved in other parts of the world, our animals have survived, and are so many ancient documents to which we can refer for information as to the animal life of ages past. This it what is meant by the term "land of living fossils," so frequently applied to Australia. This striking feature, namely, the survival in Australia of types which have long been extinct in other lands, is not confined to the higher forms such as the mammals, but is exemplified also in the lower vertebrates and also in the invertebrates. Long ago Huxley wrote, "Looking at the present terrestrial fauna of Australia, it appears to me to be very probable that it is essentially a remnant of the fauna of the Triassic, or even of an earlier age"

(Huxley, 1870); since that time many writers have emphasised the same feature.

Amongst the mammals, the monotremes, comprising the platypus and the echidnas, now confined to the Australian region, are the sole survivors of primitive mammals which retained the reptilian habit of laying eggs. In spite of this egg-laying habit and various anatomical features of a reptilian character, the monotremes are true mammals, although some authorities have argued that they are a race apart and should be removed from the mammalian class. The geological history of the monotremes is practically unknown, for no fossil monotremes have been found elsewhere than in the Australian Pleistocene (or perhaps Pliocene as well), and these differ but little from the recent forms. It has been suggested that the monotremes are related to the Multituberculata, small extinct mammals, mainly of Mesozoic age, in which the molar teeth had flattened crowns with many cusps arranged in rows, but it is probable that this view is not justified. The monotremes, then, have no close relatives among either living or extinct mammals, and Broom makes the striking statement that "the difference between a cynodont reptile and a monotreme is less than the difference between a monotreme and a marsupial, and this again not much greater than that between a marsupial and an insectivore" (Broom, 1907, p. 1059). The exact mode and place of origin of the monotremes is still a mystery, and it is possible that they originated in Australia from pro-mammalian ancestors and have never existed elsewhere.

The marsupials are the characteristic mammals of Australia, and unquestionably they belong to a very ancient and once widely distributed order which now survives only in Australia, with its neighbouring islands, and in South America, with a few stragglers in North America.

However the marsupials entered Australia it seems certain that it was at a fairly distant date, perhaps late Cretaceous, perhaps early Eocene, and that at the time of their entry they were the highest type of mammals. It is often said that the marsupials were *driven* into South America and Australia by the later evolved placental mammals, but this does not seem to be the correct expression. If that were so, some of the higher forms would have entered Australia at the same time. It seems much more reasonable to suppose that at one time marsupials were practically cosmopolitan, and that they have *survived* in Australia.

When they first reached this continent they found a large land mass with a hospitable climate and no serious competitors and then began that grand deployment or adaptive radiation which has given us the diverse types of the present day. Just as in the human sphere, so, in the animal world there are certain niches, or "professions," which demand qualifications of a particular kind suitable to the environment. In nature, by a process of evolution, types fitted for various environments and modes of life are brought into existence by modification of the original stock. This is what is meant by Osborn's term *adaptive radiation* (Osborn, 1902), and no finer example of the working of this great principle could be found than is presented by the marsupials of Australia. It is extremely probable that the earliest Australian marsupials were small arboreal creatures, whose diet was mainly insects and other invertebrates. From this stock, by a process of branching, have come the large grazing form, such as the kangaroos and wallabies, the carnivores, such as the thylacine, native cats and marsupial mice, the burrowing marsupial mole, the beaver-like wombat, the arboreal phalangers, the flying "squirrels" and other types.

There is another principle which is beautifully illustrated by the Australian marsupials and that is the principle of

convergence, by which animals which have no genetic
relationship are yet moulded by similar environment and
similar life habits into a deceptive resemblance to each
other. This analogical or convergent evolution is
splendidly exemplified in the case of the Tasmanian Wolf
(*Thylacinus*) and the northern wolf. The Tasmanian Wolf
is a cursorial carnivore with more or less the same food
and other habits as the northern wolf, and so he has
acquired the wolf form and dentition, though, of course,
there are fundamental differences between the two animals.
Indeed the northern wolf is more closely related to the
elephant than he is to the thylacine. So the wombat
resembles the beaver, and the marsupial mole (*Notoryctes*)
is closely analogous to the European mole and especially
to the Cape Golden Mole (*Chrysochloris*). So striking,
indeed, is the convergence in the case of *Notoryctes* and
Chrysochloris that so accomplished a comparative anatomist
as Cope supposed them to be related genetically (Cope,
1892). Convergence is the *ignis fatuus* of comparative
anatomy, ever luring the student into the quagmire of
false analogical reasoning.

Amongst lower vertebrates we have a living fossil in
the Port Jackson Shark (*Heterodontus*), the last survivor
of a family which was abundantly represented in the
Mesozoic. The Lung-fish (*Neoceratodus*) of the Mary
and Burnett Rivers, Queensland, is a representative of a
family of fishes which dates from the Triassic, and the
order to which it is assigned was at its zenith in the
Devonian. In our harbour lives a bivalve, *Trigonia*, which,
though similar molluscs were abundant everywhere in the
Jurassic and Cretaceous, is now found only in Australian
waters. The Anaspidacea, a group of peculiar freshwater
crustacea, found fossil in the Carboniferous and Permian
of Europe and America, are still represented in Australia

by a few forms living in Tasmania and Victoria. But I
need not give further instances of the survival in Australia
of forms which were once more widely distributed, as
indicated by their geological distribution.

Another interesting fact about the Australian fauna,
which has been stressed by many authorities, is that it
shows considerable resemblance to the fauna of South
America, and, in a less degree, of South Africa and
Madagascar. For example, South America is the only
other country in which marsupials are at all abundant.
The side-necked turtles or Pleurodira, which withdraw their
heads under their shells by bending their necks in a
horizontal plane, are the only freshwater chelonians found
in Australia, and they also inhabit South America, Africa
and Madagascar, but not the northern hemisphere. A
curious, extinct, horned turtle, *Meiolania,* was first found
in the Pleistocene of Queensland and of Lord Howe Island,
later in the Eocene of Patagonia. The Iguanidæ are found
in South America, Madagascar and Fiji. The characteristic
frogs of Australia find their nearest relatives in greatest
abundance in South America. The same affinity is shown
in the fresh water crayfishes and in several groups of
insects, as well as in the flora.

There can be no doubt then, that, in the case both of
animals and plants, southern lands possess certain
terrestrial and freshwater types in common, which are
not found in the north, or are poorly represented there.
How is this to be explained in view of the wide and deep
ocean spaces now separating the southern continents?
This subject has been debatable ground for many years,
and in entering upon it I may be accused of rushing in
where angels fear to tread, but it is necessary to review
the question in a very brief manner.

We have two opposed schools, one represented by such authorities as Hooker, Huxley, Forbes, Hedley, Baldwin Spencer, Dollo, Ortmann, Osborn, Harrison, who maintain that in the geologic past there was a land bridge in some form or other connecting South America with Australia, probably by way of the Antarctic continent, which then extended further north and united South America, South Africa, Australia, and New Zealand. By means of this land bridge animals and plants were able to pass from one side to the other. There are various forms of this hypothesis, and its supporters are not unanimous as to its position, its extent, or the time when it existed, but the usually accepted view is that advocated by our fellow member, Mr. Charles Hedley, who believes that in the Mesozoic or older Tertiary the Antarctic continent had a mild climate, and extended northwards in narrow strips so as to join Australia, South America, and possibly South Africa, and that this continent was unstable, at one time dissolving into an archipelago, at another resolving itself into a continent.

The other school, some of the leaders of which are Wallace, Lydekker, Wortman, Haseman, Matthew, Andrews, Loomis, Noble, and Longman, believe, on the contrary, that the resemblances between the life forms of South America and of Australia are better explained by regarding them as the survivors in southern lands of forms which originated in the north or in the tropics, and have been pressed southwards by higher forms, until they found a safe refuge in the "dead ends" of the southern continents. There they have pursued a more or less parallel course, while preserving certain common characteristics inherited from their northern ancestors.

It will be observed that there is a brilliant array of counsel on both sides, and one would conclude that certain

crucial facts must be lacking. To decide this knotty but
exceedingly interesting and important question one needs
to have a due appreciation of the evidence derived from
many different sources; physics, geology, geodesy,
geography (ancient and modern), zoology, botany,
palæontology, must all be laid under contribution, but
most of all, an open mind is necessary, and that, perhaps,
is the rarest qualification of all. Man is fond of paradox,
and it may be that the southern school is inclined to
emphasise certain striking cases of affinity shown by the
animals and plants of South America and Australia, which
are now so widely separated that we would not expect to
find much community, while slurring over the differences
between the faunas of the two regions, and giving too
little weight to the undoubted resemblances between those
of Asia and Australia. On the other hand, where it is
necessary to their argument, the northern school are prone
to assume the former existence of certain groups where
there is no good evidence for this belief. And one must
be careful to keep the time factor always in view, for the
animals and plants concerned are not all of the same
geological age; the ancestors of *Neoceratodus*, for example,
if they reached Australia by land, possibly used a bridge
which was destroyed before the marsupials could avail
themselves of it.

It is usually impossible to determine the place of origin
and the migration routes of a race of animals from the
present distribution of its members. This is no doubt
a truism, but its incidence is sometimes overlooked, perhaps
unconsciously. It has been argued by Baldwin Spencer
(1896, pp. 178-179) and Hedley (1911-1912, p. 84) that
the relatively greater proportion of marsupial types in
southern Australia, and particularly in Tasmania, indicates
a southern origin. Longman, on the other hand, combats

this view, and, from the wealth of diverse marsupial
genera in northern Australia and New Guinea, he would
deduce that the marsupials entered from the north (1924,
pp. 2-4). These arguments have little value. The main
radiation of marsupials, beyond doubt, occurred on the
Australian mainland, and these now found in Tasmania
and the islands to the north are derived from mainland
forms. The Tasmanian Wolf and Tasmanian Devil, now
confined to Tasmania, formerly lived on the Australian
mainland as well, and it seems very probable that they
were exterminated there by the fierce competition of the
dingo, which, on his arrival, found his way to Tasmania
barred by Bass Strait. Indeed, Tasmania, in a very minor
degree, bears the same relation to Australia as Australia
to the rest of the world, or as Madagascar to the African
mainland; it is a sanctuary.

There is no more important clue to the origin and
migration of races than that afforded by palæontology.
When the geological record is fairly complete we can
write the history of a race with some confidence, but the
record is very seldom even reasonably complete, and
negative evidence is of little value. We can explain
perfectly why the tapirs are found to-day in southern
America and the East Indies, for their bones are scattered
along the trail across the northern hemisphere, and many
similar cases of discontinuous distribution can be explained
in the same manner. The presence of the three surviving
Lung-fishes, *Lepidosiren* in South America, *Protopterus* in
Central Africa, *Neoceratodus* in Queensland, is no proof
that these continents were formerly connected towards
the south, for the Dipnoi as mentioned above are a very
ancient group, and were once widely distributed in the
north as well as in the south. So the present distribution
of the Araucaria, often cited in support of the Antarctic

land bridge, is valueless, and the same is the case with the Iguanidæ. What is regarded as the oldest struthious bird, a group now confined mainly to the southern hemisphere, comes from the Pliocene of India; moreover, the Struthiones are not a natural group, and the different members have probably evolved independently in the various regions where they are now found.

It is unsafe to generalise on the recent distribution of freshwater animals, for it is known that these are often descended from ancestors with a marine habitat. Thus the little eel-gudgeon, *Galaxias,* found in Australia, New Zealand, South America and South Africa, was once one of the minor props of the Antarctic bridge, but some species enter the sea freely, and its value as evidence for former land connections is very slight. So with the Phreatoicidæ, a group of crustaceans whose affinities are still uncertain, but which are represented in Australia, New Zealand, and South Africa; according to Nicholls (1923-4, p. 103), they are probably descended from marine ancestors. The southern crayfishes, Parastacidæ, may also be descended from tropical marine forms, which have since become extinct (Geoffrey Smith, 1909, p. 214). So *Meiolania* was in all probability able to cross the ocean and needed no continuous land bridge (Anderson, 1925, p. 241). If, as Tate Regan says (1909, p. 779, f.n.), the freshwater fishes of Australia, with the exception of the archaic types *Ceratodus* and *Scleropages,* all belong to marine families, genera, or species, then they give no assistance in the study of the former distribution of land and water.

Probably the mammals afford the best evidence of former land connections. Few mammals are able to swim across an ocean stretch exceeding twenty miles, and, though some may be unwilling passengers on floating logs or natural rafts, such cases are, and no doubt have always been

rare. Yet we must not overlook the possibility of distribution across straits or narrow seas by this method, especially in the case of small arboreal animals. It is generally supposed that the Australian Muridæ gained admission in this manner, and it is even possible, as Bensley suggests (1901, p. 262), that the marsupials came in by the same means. My colleague, Mr. A. R. McCulloch, informs me that, when he and Captain Hurley were on the Fly River estuary, New Guinea, floating islands of vegetation were frequently seen, and he estimated that some of these islands would easily travel over fifty or more miles of sea. But, generally speaking, if we find members of the same order or family of mammals on land areas now separated by ocean, we may fairly assume that these lands were once connected.

It is therefore important to consider the affinities and previous history of the Australian marsupials. Huxley suggested that the stem form of all existing marsupials is to be found in the American opossums, the Didelphiidæ, and this view is now generally accepted. Now the Didelphiidæ have a very long history. In the upper Cretaceous, Belly River, Alberta, was found a primitive opossum, *Eodelphis browni*, which is the oldest undoubted marsupial. It is described by Matthew (1916) as related to the family Cimolestidæ, which cannot at present be separated from the Didelphiidæ by any distinction of family rank. It is a striking fact that the living Didelphiidæ have descended with but little change from Cretaceous ancestors, for it proves that the roots of the marsupial stock are to be sought still further back, and it also testifies to the conservatism of the order. The Didelphiidæ are represented in the early Tertiary of Europe also, and they were apparently fairly wide spread in the Eocene and more particularly the Oligocene of

Europe and America. The oldest South American marsupial, *Proteodidelphys,* is from the upper part of the Chubut formation of Patagonia, and is assigned by Osborn (1910, p. 515) to the lower Eocene. On present showing then, the probabilities are that the marsupials originated in the northern hemisphere, but we must not overlook the possibility that they may yet be found in the Cretaceous of South America.

Did the marsupials then travel to Australia across the Alaskan bridge and through Asia? Or did they originate in Asia and radiate from that centre, reaching Australia by the Malayan chain? Or did they enter Australia from South America across the Antarctic continent? We are yet some way from being able to answer these questions. No marsupial fossils have yet been found in Asia or in the Antarctic, and none in the Mesozoic or earliest Tertiary ·of Australia, and, while these gaps remain, these questions can not be answered satisfactorily. Asia is still largely unexplored so far as its palæontology is concerned, but, through the researches now being pursued so vigorously by the American Museum of Natural History, we are at last beginning to realise what an important part this continent played as the homeland and centre of dispersion ·of the faunas of America and Europe. So far the American explorers have not described any fossil marsupials from Central Asia, but, according to Professor H. F. Osborn, Mr. Walter Granger has discovered a number of small mammalian jaws, found in small pockets above the *Protoceratops* zone of Djadochta. So far as examined, these animals are of archaic type, and it is hoped that they will prove to be the long-sought mammals of either Upper Cretaceous or Lower Eocene Age (Osborn, 1924). Should marsupials be found in the ·Mesozoic or early ·Tertiary of Asia, and especially should they prove to be

ancestral to Australian forms, the evidence for a northern
point of entry into Australia would be immensely
strengthened. On the other hand, if marsupials are
found, not in Asia, but in fossiliferous beds in the
Antarctic, those who favour a southern origin would have
powerful argument.

One of the strongest arguments, to my mind, in favour
of the Antarctic bridge, is afforded by the presence in the
Miocene of Patagonia of the "Sparassodonts" or
Borhyaenidæ, cursorial marsupials, some of them as large
as, or larger than the Tasmanian thylacine, and so similar
to it that they have been placed in the same family,
Thylacinidæ. Matthew considers that the characters which
link the sparassodonts with *Thylacinus* and distinguish
both from the didelphids, have been independently
acquired in adaptation to a predaceous cursorial life
(Matthew, 1915, p. 265). Recently, however, Elmer Wood
(1924) has carefully tabulated the osteological characters of
didelphids, sparassodonts, *Thylacinus* and dasyurids, and
finds that the sparassodonts show preponderating
thylacinid affinities. It is not impossible, of course, that
parallel evolution may account for the undoubted resem-
blance between the two forms, for it is astonishing what
parallel or convergent evolution can do; witness the case of
Thoatherium, one of the Litopterns, an extinct order of
hoofed mammals, which in its osteology shows a remarkable
resemblance to the horse, though belonging to a different
order (Scott, 1913, pp. 499, 652, 654).

There are conflicting views as to the time when the
marsupials first reached Australia, the estimates ranging
from Jurassic until well into the Tertiary. A late arrival
of the marsupials is deduced chiefly from the fact that
the Australian radiation has advanced only a short dis-
tance and produced families, not orders (Bensley, 1903,

pp. 206-207). But it is conceivable that their evolution
has proceeded but slowly on account of the stable conditions
under which the animals were living. Gaudry (1906, pp.
31-32) has emphasised the fact that, both in South America
and Australia, the march of evolution has been slower than
in the north, and we have the case of the Didelphiidæ,
which have persisted almost unchanged since Cretaceous
times. Hence it is possible that marsupials have inhabited
Australia since the Mesozoic, though we have no positive
evidence of their presence before the Pliocene, which is
the probable age of *Wynyardia,* the oldest known Aus-
tralian marsupial. The paucity of pre-Pleistocene
marsupial remains found in Australia is astonishing, and
there is a strong hope that vigorous prospecting will reveal
to us the ancestral forms from which our modern types
and such giants as the extinct *Diprotodon* have been
derived. *Wynyardia* is now generally regarded as a
primitive Diprotodont, and it must have had a long line
of ancestors somewhere, probably in Australia.

Assuming that the sparassodonts and *Thylacinus* are
members of the same family, and that the starting point
of the family is to be sought either in Australia or in
South America, it is important to discover, if possible,
when the trans-Antarctic passage took place. If it was
during or since the basal Eocene period, we should expect
to find descendants of some of the peculiar South American
mammals of that period still extant in Australia, for it is
not to be supposed that a land bridge which would permit
the passage either way of a thylacinid would be a barrier
to the passage of some at least of the edentates and hoofed
mammals which then existed in South America in great
variety. The alternatives suggested by Elmer Wood (1924,
p. 85) are that "There may have been a discontinuous
southern connection between South America and Australia

during the late Cretaceous or early Tertiary. Or perhaps the marsupial adaptive radiation began in Holarctica by the Upper Cretaceous. By the Paleocene the Didelphiidæ and, perhaps, the Dasyuridæ, Myrmecobidæ, Thylacinidæ, and the pre-diprotodonts were already in existence. The competition of the placentals would then have limited the marsupials (except the opossum) to South America, (with opossums, thylacines and pre-diprotodonts) and Australia (with myrmecobids, dasyures, thylacines and pre-diprotodonts)." It is doubtful whether we are justified in going beyond this statement at the present time, and we must wait the discovery of the hypothetical common ancestor of the sparassodonts and *Thylacinus* before any more definite conclusion can be reached as to the place of origin and migration route of the Australian marsupials.

As regards other lines of evidence, mention must be made of recent papers by Metcalf (1923) and Harrison (1924), in which they stress the present distribution of the amphibia as indicating the former existence of a land connection between South America and Australia. They have sought to strengthen their argument by pointing to the existence of similar opalinid parasites in South American and Australian frogs. Noble (1922, pp. 63-74) and Dunn (1923) on the contrary think that the distribution of the Anura can be explained without assuming such a land connection. Harrison further reinforces his contention by appealing to the Temnocephaloid parasites of the Parastacidæ, and it may be that there is considerable force in .his argument. But, on the other hand, it is possible that the occurrence of related parasites on certain hosts, indicates merely that the ancestors of the parasites infested the ancestors of the hosts. In this connection we may quote Johnston on the trematode parasites of frogs (1913, p. 276-277) · "When the amphibian ancestors of the

frogs appeared in the world, long before the frogs them-
selves, they became in this way infected with a number
of forms of trematodes. . . . As the descendants of those
early amphibians dispersed to the four corners of the
earth, they took their parasites with them, and while the
old amphibians have become altered very considerably, the
parasites have probably altered only a little, but still have
altered . . . It is a remarkable fact that of the six species
of flukes known to-day as parasites of frogs inhabiting
Southern Asia, four of them appear to find their nearest
relatives in flukes from Australian frogs . . . The mutual
relationships of these groups of trematodes support the
view that the Anura originated somewhere about the centre
of the Palæarctic region and migrated both westwards
and south-eastwards . . . The Australian forms must have
found their way down here before the separation of the
Australian continent from South Eastern Asia, a separation
which is generally supposed to have taken place somewhere
about Cretaceous or Eocene times.''

Ortmann (1902, pp. 297-303) compares the Tertiary
mollusca of Patagonia with those of Southern Australia
and New Zealand, and lists a number of genera from the
two regions which show close affinity. But Iredale informs
me that later studies have shown that the resemblances
are mostly illusory, and that only a few forms doubtfully
indicate relationship of Australasian forms with South
American. On the other hand he states that there are
very few Australian land shells which cannot be linked
with northern forms.

Birds, on account of their powers of flight, are but poor
indices to former land connections, but, according to Iredale,
with very few exceptions Australian birds are closely
related to those of the northern hemisphere; the exceptions
are the penguins. albatrosses, petrels, Cape Barren Goose,

and the lyre bird, the last having no known relatives
anywhere.

The evidence of plants, like that of the animals, is
somewhat conflicting. There are a number of genera and
species common to Australia and South America (Rodway,
1911, Andrews, 1916, pp. 219-220), yet there are striking
differences also between the floras of the two countries, and
many Australian plants have undoubtedly come from the
north, and, if *Phyllocladus,* represented to-day by one
species in Tasmania, one in New Zealand, and one in
Borneo, is related, as several palæobotanists think, to
Protophyllocladus, from the Cretaceous of Europe and
North America, it surely must have come from boreal lands.
Mr. E. C. Andrews has recently (1916) discussed the
problem from the point of view of the flora, and he strongly
supports the view that there was a land connection between
Australia and Asia in late Cretaceous, and that this formed
a bridge by which animals and plants were able to reach
Australia.   Geological and geographical considerations
favour this view, for a rise of the sea floor between Asia
and Australia of about 1,000 metres would unite the two
land masses, except for certain deep, narrow trenches,
which may not be of great geological age, while an elevation
of over 2,000 metres would be necessary before Antarctica
would unite southern continents.

It will be seen that we have yet much to learn regarding
Australian biological problems, and it behoves us to be up
and doing before it is too late.   Our marsupials, for
instance, have been preserved to us because of their
isolation, but now, that protection has been removed.   Man
and his domestic animals, and others, such as the fox
and the rabbit, which he has thoughtlessly introduced,
have made serious inroads on the ranks of our
indigenous animals, and some have been already exter-

minated, while others are fighting a losing battle. The Native Bear (*Phascolarctos cinereus*) has become very rare in New South Wales, though it is still fairly plentiful in Queensland, and is re-establishing itself in sanctuaries in Victoria. The Rabbit Bandicoot (*Thalacomys lagotis*), once plentiful in New South Wales as far east as Bathurst, has not been reported in this State for many years. The Hare-Wallaby (*Lagorchestes leporoides*) of the interior of New South Wales, has not been recorded since the 'eighties and may be extinct. The Banded Anteater (*Myrmecobius fasciatus*), a very interesting marsupial type, is now extinct in South Australia and very rare in Western Australia. The Honey-Mouse (*Tarsipes spenseræ*) one of the most specialised marsupials, which is almost dependent upon the blossoms from which it derives its sustenance, is being steadily driven from its haunts by "burning off" and other operations incidental to land industries. Some of the indigenous placental mammals, too, have already disappeared from localities where once they were abundant. The Stick-nest Rat (*Leporillus conditor*), once plentiful on the plains of the Lower Murray and Lower Darling, is now known only on the barren Nullarbor Plain of South Australia. The Tasmanian Wolf, one of the most important marsupial types, is apparently doomed, for it is now rare, and it is difficult to see how it can be saved from extinction.

Several of our birds, too, are either extinct or verging on extinction. The Kangaroo Island Emu was common when the early voyagers called at the island, but none survive to-day. The Flock Pigeon (*Histriophaps histrionica*), once very abundant, is now very rarely seen; and the red-shouldered Grass Parrot (*Neophema pulchella*), common around Sydney when the first settlement was formed, is now exceedingly rare. The Spinifex Parrot

(*Geopsittacus occidentalis*), of Central and Western Aus-
tralia, has not been seen for the past twenty years; and
the Coach Whip bird of Western Australia (*Psophodes
nigrogularis*), is extinct, though the eastern species is still
common.

This list might be greatly extended, but it suffices to
show the necessity for protective measures such as the
setting aside of reserves and sanctuaries in various types
of country, where our indigenous animals may have an
opportunity to live and rear their offspring undisturbed
as far as possible.

It is probable that no amount of protection will save
certain of our marsupials from extinction in the near
future, and it is very desirable that all possible data
concerning them should be secured as soon as possible.
Collections adequate for record should be secured before
it is too late, otherwise it may happen that a species will
pass away and be represented in our national collections
only by a few skins and skulls, or perhaps by none at
all. Professor Wood Jones (1924), who is doing such
splendid work on the mammals of South Australia,
mentions, for example, that a rat kangaroo, which once
swarmed on St. Francis Island, Nuyts' Archipelago, was
recently exterminated by cats introduced for that purpose.
No specimen is preserved, and it is now impossible to
determine to what species it belonged.

We must also undertake systematic exploration of our
Mesozoic and early Tertiary rocks, in order to discover,
if possible, when the marsupials first reached Australia,
and what the earliest forms were like. If, as generally
supposed, they have been here since Cretaceous or early
Eocene times, there must be many ancestral types embedded
in the rocks, and their discovery would undoubtedly throw
a strong light into many corners which are now dark.

I have to express my gratitude to my colleagues, Messrs. A. R. McCulloch, E. le G. Troughton, and Tom Iredale, of the Australian Museum Staff, for much cordial assistance in preparing this address, and to Mr. R. H. Cambage for some of the facts embodied in the obituary notices.

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THE ESSENTIAL OIL OF BORONIA CITRIODORA AND THE OCCURRENCE OF CITRONELLOL.

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(Read before the Royal Society of New South Wales, June 3, 1925.)

The botany of this extremely interesting and valuable Rutaceous shrub is referred to in Bentham's "Flora Australiensis," Volume 1, page 319, under *B. pinnata* var. *citriodora,* but it is undoubtedly distinct from any other species of Boronia at present known.* It is a typically alpine plant endemic in Tasmania, growing in elevated and remote locations, being especially plentiful in the neighbourhood of Cradle Mountain. Mr. Thomas Newman, of Moina, Tasmania, to whom we are indebted for the excellent supplies of material collected, has kindly furnished in correspondence much interesting information respecting the climate of the district where the plant is so plentiful, and the following extracts have been taken therefrom :—

> "This plant belongs to the snow regions where it thrives. Any quantity cân be obtained if the right time of the year is selected; that is, about Christmas time, and not later than the Easter holidays. Collection is rendered difficult, as precipitation occurs nearly all day. Even as late as November (year 1922), the country is dripping wet with incessant rain, snow and fog, and further difficulty is experienced on account of the swollen river. Rain falls on an average about 180 days per year."

The plant is known vernacularly as "Lemon-scented Boronia," which is rather peculiar in view of the fact that the principal constituent possesses a sweet rose odour; neither citral nor citronellal was detected in the comparatively small quantities of oil examined.

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* The results of a botanical investigation of this shrub by Mr. E. Cheel will probably form the subject of a paper shortly to be read before this Society.

The Essential Oil.

The leaves, on crushing between the fingers, emit a fine rose-like odour resembling citronellol, although the first impression is one of lemons, and a careful examination of its essential oil confirmed the presence of this alcohol to the extent of 80%. It is, therefore, one of the richest citronellol-bearing oils which have as yet been described. Two collections of material, totalling 166¼lbs., cut as for commercial purposes, were made from the same locality at Moina, Tasmania, by Mr. Thomas Newman.

The yields of oil from the consignments have been calculated on the weight of material as received, as at time of collection the leaves were heavily laden with surplus moisture. The author is engaged upon an investigation of several Tasmanian essential oils, but is experiencing considerable difficulty in their examination, as during the summer months decomposition takes place owing to the leaves having to be transported long distances on packhorse, which is apart from transit to a shipping port and subsequent carriage to Sydney.

The average yield of oil from this Boronia is considered to be from 0.71% to 0.93%, the lower yield being due to distillation in a large still. In common with the experience of others, it has been found that oils rich in alcohols, like citronellol or geraniol, are best distilled in small stills. The crude oil, when first obtained, is of a pale green colour, but in the course of about twelve hours it changes to a reddish-brown. On rectification by steam distillation an almost colourless oil is obtained.

The principal constituents that have so far been identified are citronellol (total, 80%), citronellol esters, principally the acetate, with some valerianate, d-a-pinene, sesquiterpene, a paraffin (M.Pt. 64-65° C.), together with small quantities of a phenolic body and free capric acid.

Economic value.—The citronellol isolated from the oil possessed the fine natural rose odour typical of this alcohol, that is, when judged by the olfactory organs, and not on chemical analysis alone. Neither citral, citronellal nor geraniol could be detected. The crude oil of this Boronia, one of the richest sources of citronellol which has yet been observed, should prove to be of considerable commercial value. Moreover, in view of the high yield, it should pay to extend the available areas of the plant by cultivating it, especially in and around its native habitat at Cradle Mountain, Tasmania. If its cultivation be not attempted there, it is not unlikely that it would do especially well in the more common alpine regions of Europe, particularly as the yield of oil is so much higher than any other natural source of citronellol.

Experimental.

The 166½lbs. weight of leaves and terminal branchlets collected at Moina, Tasmania, yielded, on distillation with steam, crude oils possessing the following chemical and physical characters:—

Date	Weight of Leaves (as received)	Yield of Oil	Specific Gravity $\frac{15°}{15}$ C.	Optical Rotation	Refractive Index at 20° C
19/4/1923	74½ lbs. (110 lbs. at time of collection)	0·93 %	0·8814	+ 3·8°	1·4611
19/12/1923	92 lbs. (120 lbs.)	0·71 %	0 8822	+ 2·8°	1·4608

Solubility in 70% Alcohol	Ester No. 1½ hours, hot sap.	Ester No. after acetylation	Percentage $C_{10}H_{20}O$ by formylation	Remarks
1 in 1 vol.	42·10 (Acid No. 4)	239·46	80·38 %	Plant just finished flowering, distilled in small still.
1 in 1 vol.	69·88 (Acid No. 5)	241·24	82·31 %	Plant in bud distilled in large still

On distillation at 10 mm., the crude oils yielded 5% boiling below 92° C., 65% between 97-110° C., 25% at 110-116° C., with 5% high boiling residue.

Phenol and Free Acid.—The crude oil was washed with 8% caustic soda solution, when about one per cent. of a mixture of phenolic and acid bodies was removed. Upon liberation with dilute sulphuric acid, they were taken up in ether. This ethereal solution was shaken with sodium bicarbonate solution to remove free acids, and the phenol was obtained by removal of the solvent. The sodium bicarbonate solution was treated with dilute sulphuric acid and the liberated acid blown off with steam. The free acid thus obtained was neutralised with ammonia solution and the silver salt was prepared; 0.2528 gram gave on ignition 0.0990 gram of silver = 39.16%. The silver salt of capric acid ($C_{10}H_{19}O_2Ag$) contains 38.9% of silver.

The phenol possessed a mixed odour of eugenol and leptospermol, but could not be definitely identified. Its alcoholic solution gave a dirty-brown colouration with ferric chloride.

Determination of the Ester.—The crude oil, after removal of free acid and phenol, was heated with alcoholic potash solution on the water bath for two hours in order to decompose the ester present, which from preliminary experiments had been found to be one of citronellol. The potassium salts were separated, decomposed with dilute sulphuric acid, and steam distilled. The volatile acids thus obtained gave, on neutralisation with ammonia solution, all the reactions for acetic acid. A small quantity of valeric acid appeared to be present, judging from the darkening of the silver salts and from the positive qualitative reactions obtained for this acid in the first

lot of oil distilled. Silver salts were prepared from the two consignments, and gave the following results on ignition :—

First Lot.—0.2030 gram of silver salt gave 0.1146 gram of silver = 56.4%.

As the ammonium salt gave the qualitative reactions for isovaleric acid, it is probably a mixture of that acid with acetic.

Second Lot.—(a) 0.3100 gram of silver salt gave 0.1970 gram of silver = 63.55%. (b) 0.7408 gram of silver salt gave 0.4716 gram of silver = 63.66%.

The silver salt of acetic acid contains 64.67% of silver.

Determination of Alcohol.—The crude oil, when freed from free acid, phenol and ester, was heated with equal weights of phthalic anhydride and benzene on the water bath for two hours. The melt was dissolved in dilute caustic soda solution and repeatedly extracted with ether. The aqueous solution, after expulsion of dissolved ether, was treated with dilute sulphuric acid and the crude phthalic acid ester was separated. This latter was then decomposed by treatment with alcoholic potash solution, and the liberated citronellol was blown off with steam. The alcohol, after distillation, was obtained as a colourless liquid with a fine rose odour, and was found to possess the following constants :—

Boiling point at 10 mm., 110-112° C.
Specific gravity, 15/15° C., 0.8612.
Optical rotation, +3.9°.
Refractive index, 20° C., 1.4572.

The silver salt of the phthalic-acid ester was prepared, and on re-crystallisation from methyl alcohol, it melted sharply at 126° C.

0.3016 gram gave on ignition 0.0790 gram of silver
= 26.19%
$C_{10}H_{19}O.CO.C_6H_4COOAg$ contains = 26.27% of silver.

The alcohol has, therefore, been definitely shown to be citronellol.

Non-Alcoholic Bodies.—The ethereal washings from the phthalic-acid ester were taken, the solvent removed, and the oil thus separated was subjected to distillation at 765 mm. with the following results.—

100 c.c. crude oil originally taken:—

		Sp. gr. 15/15° C.	Optical rotation.	Refractive index, 15.5°C.
156-180° C.	2 c c	0 870	+21 5	1.4749
180-220° C.	3 c c		+14.0	1 4751
200-220° C	2 c c		+ 4 0	1 4800
220-260° C.	10 c c.		+ 1.4	1.4900

Identification of d α-Pinene —The first fraction readily yielded a nitrosochloride which on purification melted with decomposition at 109° C The second fraction also yielded a similar derivative.

Determination of Sesquiterpene —The last two fractions were found to consist of uncombined citronellol and a sesquiterpene, but sufficient material was not available for the definite identification of the latter It was, however, recognised by the beautiful colour reactions, with bromine in acetic acid and with sulphuric acid in acetic anhydride solutions, so characteristic of sesquiterpenes

Determination of Paraffin.—From the residue left in the flask after removal of fraction 220-260° C., a saturated paraffin was isolated of melting point 64-65° C.

In conclusion I have to express my thanks to Mr. E. Cheel, Curator of the National Herbarium, Sydney, who first brought the matter of this investigation under notice, to Mr. L. C. Webster, of Sydney, who at a much later date also urged the necessity for its investigation, and to Mr. F. R. Morrison, A.A.C.I., A.S.T.C., Assistant Economic Chemist, for assistance in carrying out the same.

A THIRD CONTRIBUTION ON THE HOMOLOGIES OF THE PARASPHENOID, ECTOPTERYGOID AND PTERYGOID BONES AND OF THE METAPTERYGOID.

By H. LEIGHTON KESTEVEN, D.Sc., M.D., Ch.M.

(Read before the Royal Society of New South Wales, July 1, 1925.)

CONTENTS.

1. Definitions.

To prevent ambiguity or the constant use of alternative designations and because several of the structures, whose homologies call for discussion in the following pages, have received more than one name, it were well to adopt terms which may be used throughout the discussion and define the structures referred to by those terms. Be it understood that unless otherwise stated cartilaginous structures alone are here referred to. Figures 1, 2, and 3 are schematic drawings of a composite or complete "subocular arch," or palato-pterygo-quadrate cartilage. As far as possible the former term will alone be used.

Figures 1, 2 and 3.—-Schematic drawings of a complete subocular arch (original).

This arch is composed of an anterior "palato-pterygoid" process in front, and median "quadrate" portion, followed by a "metapterygoid" process. This last is attached to the skull by an anterior "parabasal process" and a posterior "otic process."

In figure 2, the metapterygoid process and quadrate will be recognised as the shaft and articular head of the suspensorium (W. K. Parker, et auct.) whilst the parabasal process is the "Pedicle" of W. K. Parker, the "ascending process" of Winslow and the author, and it will be shown below that it is also the pterygoid process, of authors generally, in the reptiles and the orbital process of the quadrate in birds. The palato-pterygoid process has also

been termed the pterygoid process, the palatine process, and the pars-palatina. The epipterygoid process has also been termed the columella (cranii) process.

2. Argument in Brief.

i. The subocular arch in the cyclostomes is the most primitive form of the arch, and in it we may recognise palato-pterygoid, quadrate, metapterygoid and parabasal processes.

ii. In the elasmobranchs palato-pterygoid and quadrate alone are present.

iii. In the teleosts palato-pterygoid, quadrate, and metapterygoid portions are present.

iv. In the completed amphibian subocular arch we recognise palato-pterygoid, quadrate, metapterygoid, parabasal and otic processes.

v. There is a marked and very real similarity of plan in the subocular arches of the cyclostomes, teleosts and amphibia, which may be regarded as the typical ichthyopsidan subocular arch.

    (a) In the amphibian stage the articulation for the lower jaw has been thrust far back and the metapterygoid process has been moved through an arc of a circle about its attachment to the parotic region of the skull as a centre.

    (b) In the development of the amphibian subocular arch we can recognise cyclostome, teleost, and amphibian stages.

vi. In the reptiles we can recognise quadrate, metapterygoid much shortened, parabasal process well developed, otic process and epipterygoid.

    (a) There is no valid reason to doubt that the well developed parabasal process is homologous with the structure similarly named in the ichthyopsidan subocular arch.

vii. In the birds the identity of the parabasal process with the orbital process of the quadrate is beyond question.

viii. In the Mammalia the quadrate is represented by one or other of the bones in the middle ear, and no process has heretofore been recognised as possibly representing the parabasal.

> (a) W. K. Parker recognised in part the homology of the parabasal process in Crocodilus, but failed to realise the importance thereof.

4. The metapterygoid of the teleosts, the pterygoid of the frogs and the ectopterygoid of the reptiles are homologous bones.

> (a) The metapterygoid is the only one of the three teleostean pterygoid bones developed in association with the metapterygoid process.
>
> (b) The amphibian pterygoid develops more constantly in close relation to the metapterygoid cartilage than to any other portion of the subocular arch.
>
> (c) The amphibian pterygoid is at times in its early development divorced from any precursory cartilaginous structure.
>
> (d) The primitive situation of the ectopterygoid of Crocodilus in embryos shows it to have developed in tolerably close association with the metapterygoid cartilage.
>
> (e) The ectopterygoids of Ichthyophis and certain labyrinthodonts appear to present the stages in phylogenetic development whereby they have come to occupy the position typical of lacertilians and ophidians.
>
> (f) In the young Lacerta the ectopterygoid occupies just the position of the anterior evanescent portion of the pterygoid of Amblystoma.

5. The pterygoid bones of the reptiles, birds and mammals are homologous structures.

i. (a) The echidna-pterygoid is not the homologue of the reptilian, but has been shown to be a true mammalian alisphenoid, though only the tympanic wing thereof is developed.

(b) Broom has shown that the parasphenoid of the reptiles is represented by the mammalian vomer, and its orgin from three centres does not discredit Broom's comparison.

(c) It is significant, however, that the two posterior centres of ossification in the reptilian vomer appear, in point of time, with the centres of ossification for the basisphenoid and rapidly fuse with them.

(d) Since in the earliest reptiles and labyrinthodonts the pterygoids are situated close to the mid-line much as in the chelonians, that condition must be regarded as primitive and Gaupp is wrong when he contends that the median position is secondary.

(e) He is in error also when he states that the non-mammalian pterygoid has relations only with the pars-palatina of the palato-pterygoid, in so far as he applies that statement to birds and reptiles. In these forms the relation is to the parabasal process,—not to the palato-pterygoid portion of the subocular arch.

(f) The relation of the vidian canal to the mammalian, avian and reptilian pterygoids is, in all important details, the same.

(g) The relation of this canal to the mammalian vomer and reptilian parasphenoid is also morphologically identical.

ii.(a) Beyond reasonable doubt reptilian and avian pterygoids are homologous bones.

(b) The avian pterygoid is developed quite independently of any cartilaginous precursor.

(c) The absence of a cartilaginous precursor to the mammalian pterygoid does not *per se* contraindicate the homology of that bone with the reptilian pterygoid.

(d) In certain cases the reptilian pterygoid is developed independently of the parabasal or any other process of the subocular arch.

(e) In a few cases an isolated cartilaginous precursor to the mammalian pterygoid has been observed.

(f) In several cases the portion of the parabasal process in association with which the reptilian pterygoid is developed is detached from the hinder portion.

iii.(a) Transverse sections taken through the basipterygoid process or its neighbourhood show that all the important morphological relationships of the pterygoid bones in reptiles, birds and mammals are so nearly similar as to convince that the bones are homolgous.

6. The pterygoids of Sauropsida and Mammalia and the parasphenoids of the Ichthyopsida are homologous bones.

i.(a) Watson is surely in error when he contends that the rana-branchiosaurus type of palate is not the most primitive amphibian palate. It is certainly the type of palate which most nearly approximates to the teleostean.

(b) The presence of a parasphenoid "vomer" of varying size in crocodiles and chelonians does not invalidate the thesis here defended.

(c) Certainly, were the chelonian conjoint prevomer a true vomer, as I believed when last I wrote on the subject, the presence of a second true vomer below the rostrum basisphenoidei would cause one to reconsider the possibilities of their interpretation. As Watson points out this is not so; I was in error and the chelonian vomer is conjoined prevomers.

(d) Though I was dependent on Embleton and Athey's erroneous description I was not materially misled in my interpretation of the Loxomma palate. To me it was a palate with broad expanded pterygoids meeting and possibly confluent in the midline, and also provided with so-called ectopterygoids extending between the pterygoids and maxillo-jugal border.

(e) The presence of a parasphenoid overlooked by Embleton and Athey, and recently described by Watson, introduces a true vomer into this labyrinthodont palate and increases the resemblance to the reptiles.

(f) Watson's comparison of Loxomma and osteolepid fish is peculiar. The palate of Polypterus resembles both generally and in all essential details the typical teleostean palate, and in all these the parasphenoid is large and possesses a well developed crus transversum.

(g) The relation of the bones around the nasopharyngeal canals in *Metriorhynchus brachyrhynchus* as described by Leeds and Andrews so accurately reproduces the division of the crocodilian conjoint pterygoid into three portions as postulated by myself, that though I would fain lay claim to such clairvoyance 'I prefer to doubt the interpretation given to the "many fragments" in which the structure "was excavated."

(h) If, however, that interpretation is correct then there can surely be no doubt that the conjoint pterygoid of Crocodilus represents three centres of ossification.

(i) The presence of ectopterygoids in the labyrinthodont palate does not vitiate my argument, but transfers to an earlier stage of the evolution of the palate those changes whereby the ichthyan metapterygoid came to have the anterior situation.

(j) To assume that the pterygoids of Rana and Loxomma are homologous structures and that the lateral situation in Rana is secondarily derived from the median situation in Loxomma, is to make an assumption entirely at variance with the facts of development, and of evolution as evidenced in the various stages of ontogeny of the cyclostomes, fishes and amphibians.

(k) Such an hypothesis may be supported by the citation of a complete series of fossil palates intermediate between the two extremes.

(l) Such a series may, however, with equal justification be studied from z to a in place of from a to z as arranged by the advocate of the hypothesis.

ii.(a) There is nothing inherently objectionable in a theory which postulates the replacement of an azygous element by paired elements and maintains that the replacing elements are entirely homologous with the median element which they replace.

iii.(a) A careful study of the course and morphological relationship of the ramus palatinus nervi facialis and arteria carotis interna, with its terminal branches, cerebral and palatine arteries, to the ichthyopsidan parasphenoid and reptilian and mammalian pterygoids, indicates that there is

nothing in these relationships to contraindicate that the bones are homologous.

(b) Gaupp is in error when he states that the internal carotid artery alone traverses the parabasal canal in chelonians.

(c) Demonstrably in several cases and probably in all reptiles the cerebral artery enters the cranial cavity through a short bony canal (the canalis arteriae cerebralis) unaccompanied by any nerve. Up to the branching of the canal the internal carotid artery and palatine ramus of the facial nerve run side by side in the parabasal canal; in front of the branching the nerve is accompanied in the canal by the palatine terminal branch of the internal carotid artery.

(d) In its posterior part the parabasal canal undoubtedly tunnels the substance of the parasphenoid bone.

7. The occasional association of the reptilian pterygoid with the parabasal process is a secondary, acquired, relation.
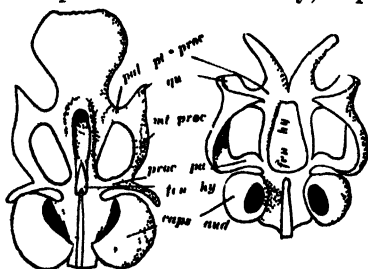
Figure 4—Chondrocranium of young Petromyzon (from Gaupp, 1906).
Figure 5—Chondrocranium of young Bufo (from W. K. Parker, 1876).

3. The Evolution of the Subocular Arch.

I. Subocular Arch in the Cyclostome.

As illustrating the subocular arch in the cyclostome, that of Petromyzon is selected. This selection is made because it is deemed undeniable that the early configuration of the

subocular arch in Rana and the Batrachia generally owes
its similarity to that of Petromyzon to community of
origin. This being so, the subocular arch of the young
Petromyzon pretty clearly presents a more primitive and
less specialised condition than that of Bdellostoma.

My drawing is from Gaupp (1906) after Parker (1883)
(Fig. 4). For purposes of comparison I have reproduced
a drawing (Fig. 5), of the early chondrocranium of *Bufo
vulgaris,* W. K. Parker (1876).

With these drawings before one, and one's knowledge
of the subsequent history of the structures in the teleosts
and amphibia refreshed, it is impossible to question the
identification of this subocular arch as the palato-pterygo-
quadrate of those other forms.

From Bufo we learn to identify the most anterior portion
as the quadrate; the transverse bar in front as the palato-
pterygoid; the longitudinal para-orbital rod behind the
quadrate as the metapterygoid process, and the posterior
transverse portion as the parabasal process or pedicle of
W. K. Parker (1871). These identifications have been made
with complete confidence in their verity, after having
compared the development of the subocular arch of Bufo
and Rana with that of the teleostean subocular arch.

In parenthesis it may be stated that the so-called postero-
lateral cartilage of Petromyzon (not figured) is indubitably
homologised correctly when compared with Meckel's
cartilage.

Certain morphological features in this arch call for
special emphasis:—

1. The palato-pterygoid portion is pre- and subocular.
2. It is separated from the metapterygoid process by the
   quadrate.
3. The metapterygoid process is not directly attached to
   the cranium.

4. The parabasal process is well developed.

5. The parabasal process gains attachment to the basis cranii just at the level of the posterior limit of the fenestra hypophyses.

6. The parabasal process lies below and in front of the foramen prooticum and is doubtless crossed superiorly by the first and second branches of the fifth nerve and the palatine branch of the seventh.

7. It lies diagonally below the antero-ventral limit of the auditory capsule.

8. In the last three features its relations are precisely those of amphibian parabasal process.

II. The Subocular Arch in the Elasmobranchs.

There can be no doubt that a specialised condition of the subocular arch is presented by the structures in the generality of sharks and rays (Fig. 6). We have here a
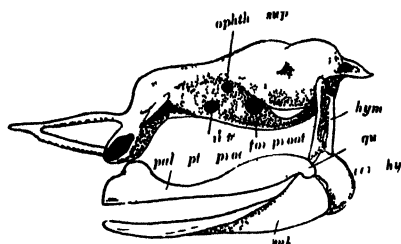
Figure 6.—Skull of Carcharhinus (original).

hyomandibular cartilage attached medially to the parotic region of the skull and distally bearing the palato-quadrate in front. Meckel's cartilage behind and below, and also behind this the ceratohyal. Though it be undoubted this is a specialised condition it were well to establish that fact by taking note of the modifications presented within the Elasmobranchii before passing to the Teleostomi and higher Ichthyopsida. Among the modifications particularly note-worthy and pertinent to the present discussion is that

which leads to the suspension of the lower jaw from the hinder end of the palato-quadrate. This may be interpreted as indicating that as the more primitive condition the quadrate is properly a constituent of the preoral arch and not, as might be adduced from the development of Salmo, of the postoral arch. This deduction is verified by the development of the arch in Petromyzon and the Batrachia. It is to be remarked that at least three modifications are present at the junction of the hyomandibular and the two oral arches. 1. The hyomandibular cartilage articulates with both and there is also an articulation between the palato-quadrate and Meckel's cartilage (Chiloscyllium and Carcharhinus Fig. 7). 2. The hyomandibular cartilage
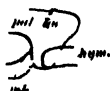
Figure 7.—Articulation of the Hyomandibular, palato-quadrate and Meckel's cartilages in Carcharhinus (original).

Figure 8.—Articulation of the Hyomandibular, palato-quadrate and Meckel's cartilages in Urolophus (original).

Figure 9.—Articulation of the Hyomandibular, palato-quadrate and Meckel's cartilages in Squatina (original).

finds attachment to the palato-quadrate only (Urolophus Fig. 8). 3. The hyomandibular is attached to Meckel's cartilage only (Squatina Fig. 9). The development of an ascending process from the hinder end of the palato-quadrate which comes to articulate with the post-orbital region at the side of the skull in certain forms (Heterodontodiae, Notidanidae) to give rise to the amphystylic arrangement may be regarded as significant and perhaps a further indication of the plasticity of the arch responsible for its peculiar specialisation.

Quite accurately and in general terms the elasmobranch preoral arch and hyomandibular cartilage, may be described

as together constituting a subocular arch situated, as the
term suggests, below the orbit and extending outward,
downward and forward, behind it to the point of suspension
of the lower jaw and thence forward, upward and inward
to the symphysis; but it is a subocular arch in which the
whole of the true post-quadratic portion has been aborted
in the adult. A small metapterygoid process is present
in early stages of development, but is evanescent.

III. The Subocular Arch in the Teleosts.

Whether or no Parker is correct in his description of
the quadrate in Salmo (1874), is a question that remains
for further investigation. According to Swinnerton (1902)
Meckel's cartilage and the palato-quadrate cartilage, with
its metapterygoid process, are differentiated out of pro-
cartilage without any segmenting off or re-arrangement
and fusions. Be this as it may it is apparent that in the
majority of the teleosts there is ultimately developed a
nearly complete cartilaginous subocular arch, which
occupies essentially the same positions and relations as the
subocular arch of the cyclostomes. This arch (Fig. 10)
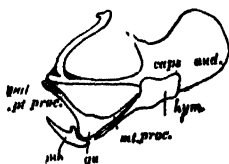
Figure 10.—Chondrocranium of Gastrosteus (from Swinner-
ton, 1902).

is the palato-pterygoid cartilage, and it is readily differ-
entiated into anterior palato-pterygoid portion, middle
quadrate and posterior ascending or metapterygoid pro-
cess. The palato-pterygoid portions do not meet in a
symphysis in front, as in the case of the elasmobranch
palato-quadrate cartilage, but articulate in front of the
orbit with a lateral process of the ethmoid. The quadrate
lies well forward lateral to and below the orbit, and from

this point the metapterygoid process extends inward,
upward and back, parallel to and in front of the hyomandi-
bular cartilage, by which it is ultimately slung to the
parotic region of the skull.

There is some variation, more particularly in the shape
of the metapterygoid process. The description given above
applies particularly to such forms as Gastrosteus; in *Salmo
salar* the metapterygoid process is much broader (Parker
1874), that of Lepidosteus (Parker 1882) is intermediate
between the two, that in *Salmo fontinalis* (Winslow 1898)
is still more expanded.*

IV. Subocular Arch in the Amphibia.

That form of the amphibian subocular arch which most
nearly resembles the teleostean is assuredly to be regarded as
the most primitive. Winslow (l.c.) has described and drawn
several amphibian chondrocrania and from the material
he places at our disposal we shall draw later on, but at
present the most significant development is that of Rana,
as given by Parker (1871). The hyomandibular and
symplectic cartilages are no longer responsible for the
attachment at the hinder end of the subocular arch to the
skull. There is a complete subocular arch attached in
front to the pre-ethmoidal expansions and behind to the
parotic region of the skull (Fig. 11). This subocular
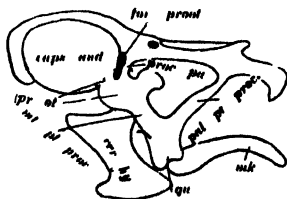
Figure 11.—Chondrocranium of Rana (from Parker, 1871).

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*In Lepidosteus the posterior end of the metapterygoid
articulates with the cranium according to W. K. Parker (1882).
After carefully reading Parker's description I am still uncertain
as to the relation of the articulation to the foramen prooticum,
internal carotid artery and the palatine branch of the facial
nerve.

arch, like the last, is situated around the orbit and below it; like the last it may be readily differentiated into anterior pterygo-palatine portion, a middle quadrate and a posterior ascending metapterygoid process. In addition to these, parabasal and otic processes are clearly recognisable.

V. The Subocular Arch in the Ichthyopsida.

A survey of the four forms of the subocular arch now briefly passed in review cannot fail to impress the surveyor with their unity of plan and convince him of the identity of their components, and at the same time such a survey must lead him to a willing acceptance of the truth under-lying the contention that the elasmobranch form is a special modification deprived of the post-quadratic com-ponents, but for all that, essentially one with the rest of the Ichthyopsida and the cyclostomes. The varying form of the arch, relation to the hyomandibular cartilage and the development of the amphystylic articulation has been quoted as evidence of its plasticity; we may now add the complete fusion of the arch with the various expansions of the cranial basal plate in the Chimaeroids as a further resultant of that plasticity.

Omitting the elasmobranch condition from further consid-eration we may speak of a characteristic ichthyopsidan type of subocular arch and we may now refer to the schematic diagram of an earlier page as a drawing of the subocular arch of this type.

At the risk of wearisome repetition it is again pointed out that these diagrams, which faithfully represent the arch in the Amphibia, also represent the arch in the Cyclo-stomes with the addition of an otic process and the back-ward displacement of the articulation of the lower jaw.

It is particularly noted that the amphibian attachment to the cranial basal plate by the parabasal process faith-fully reproduces the parabasal process of the cyclostome.

It should be realised also that the attachment of the front of the arch, *viz.*, the palato-pterygoid process to the ethmoidal region of the skull, as in the teleosts, in place of to one another by symphysis as in elasmobranchs is also a return to the primitive.

Although the teleosts present in their cranio-visceral skeleton many variations of an adaptive nature, yet the great majority retain the articulation of the lower jaw in its primitive position well in front of the posterior limit of the skull. In the aggregate then we may describe the teleostean quadrate as being situated at or near the centre of the subocular arch, and the direction of the metapterygoid process and hyomandibular cartilage is upward and *backward*, as well as inward from this point. There are, however, exceptions to this; Thyrsoidea (Fig. 12), one of the

Figure 12.—Skull of Thyrsoidea (from Boulenger, 1904).

muraenid eels, is a striking example, showing backward displacement of the lower jaw articulation and forward rotation of the proximal end of the suspensorium.

In the Amphibia the gradual displacement of the quadrate backwards and resulting rotation of the metapterygoid process is clearly shown by Parker, whose figures are here reproduced (Fig. 13).

It is also important to point out that in the progress of development the subocular arch in the amphibia passes through clearly recognisable cyclostome and teleostean stages before reaching the amphibian. This conception is of importance not only because, as already stated, it indicates for the cyclostomes and the amphibians a community
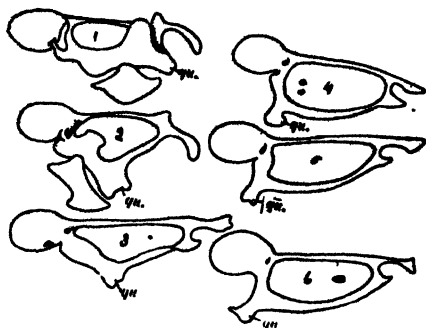
Figure 18.—Diagrams showing the changing form of the sub-ocular arch in Rana (from Parker, 1871).

of origin, but because with fuller knowledge it includes the whole of the fishes in the same community of origin, clearly indicating three grades of complexity in development:—Cyclostome, fish, amphibian. Further, the lowly organisation of the cyclostomes is such as to decide us in unanimously regarding them as primitive members of the vertebrate series. If this last conception means anything to a modern zoologist it means that the organism approaches nearly to the common progenitor of the vertebrates.

We are therefore led to interpret the subocular arch of the Sauropsida in terms of that of the Ichthyopsida, and more particularly in terms of the early stages of development of that arch, remembering that some of the later features may be specialisations peculiar to the amphibia.

So far as I have gone I believe that in the interpretation of the various components of the varied subocular arches, I have introduced only one new suggestion, and that is, that the structure which I have termed the parabasal process is always homologous. To this suggestion I believe no exception can be taken.

It is now desirable to point out that, though this arises in the cyclostomes as a lateral process of the cranial basal plate, it first appears in many, if not all amphibians as

an independent centre of chondrification and its fusion
with the cranial wall is, therefore, a secondary phenomenon.

VI. The Subocular Arch in the Reptiles.

The pterygo-quadrate cartilage of the Reptilia has been
figured by several observers. Howes and Swinnerton
(1901) traced its development very carefully in Sphenodon.
Kunkel (1912), by beautiful wax model reproduction, shows
its form and relation in a very young *Emys lutaria*.
Broom (1903) has figured the cartilages in several lacerti-
lians. Amongst all these there is a remarkable similarity,
which, remembering the diversity of the reptiles from which
they are derived, gives guarantee that throughout the
class there are no important departures from the form
figured. I have reproduced in outline two figures from
Kunkel, two from Howes and Swinnerton, and five from
Broom (Figs. 14 to 18).
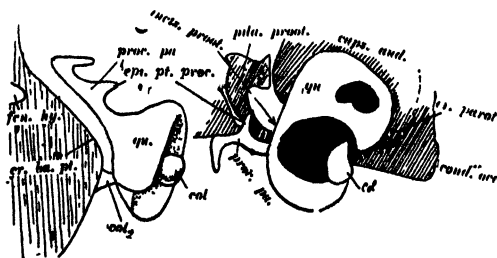
Figures 14 and 15.—The subocular arch in Emys lutaria
(from Kunkel, 1912).
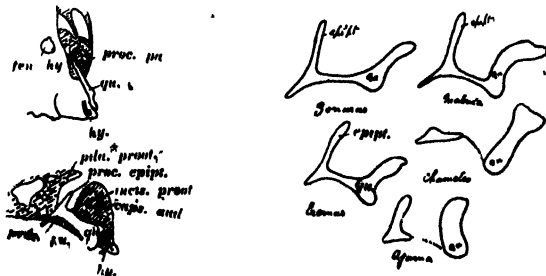
Figures 16 and 17.—The subocular arch in Sphenodon
(from Howes & Swinnerton, 1901).
Figure 18.—The subocular arch in five Lizards (from Broom,
1903).

Although the anterior process of the quadrate has always been termed the pterygoid process in the past, an examination of these figures must surely convince that it is not a pterygoid process in the ichthyopsidan sense of the term. *This* process is developed in close proximity to the side of the skull base, from the inner end of the quadrate, *that* is developed in the tissue on the outer side of the orbit cephalad from the outer end of the quadrate. It is a fact that *this* like *that* is an anterior process of the cartilage wherefrom the quadrate bone is developed, but there the resemblance ceases. Kunkel (p. 741) says,—"The pars palatina (parabasal process) arises from the anterior end of the *median* aspect of the pars quadrata, near its ventral angle."

It will be noted that this process (which I propose to term the parabasal process) lies practically parallel to the palato-pterygoid process of the Ichthyopsida, but is situated in a totally different position. It will be remembered that the quadrate in the teleostean subocular arch lies much further forward than in the amphibian, and it is patent that in the Reptilia the metapterygoid, whose lower end was rotated back in the Amphibia, has been considerably shortened. Now had the palato-pterygoid process persisted in its posterior portion it should be found projecting down, outward and forward from the outer end of the metapterygoid just proximal to the articular head.

There is nothing in the history of the evolution of the subocular arch which would lead us to believe that the parabasal process is the palato-pterygoid process.

It might appear that if the metapterygoid process of the teleostean subocular arch had been shortened and the palato-pterygoid process had lost its attachment to the ethmoid and had been drawn directly back with the shortening of the posterior process it would come to lie in just

the position occupied by the parabasal process. Such an explanation as the above involves an absolutely gratuitous assumption in the absence of any evidence presenting the intermediate stages. Now, though the explanation just given has never, as far as I am aware, been stated in so many words, it has been tacitly accepted by all observers, for it is only by such means that the palato-pterygoid process can have come to occupy the position of the parabasal process.

It is conceivable that the earlier condition in the chondrocranium of Amblystoma and other Urodeles, as figured by Winslow (l.c.) and others may be quoted as an intermediate stage. There is present here a veritable palato-pterygoid process not attached anteriorly to the ethmoidal cartilage and lying apparently in a very similar situation to the parabasal process (Figs. 19 and 20). A more
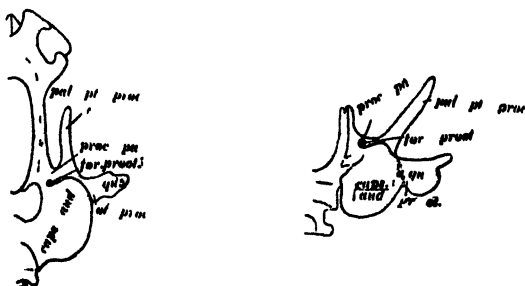
Figures 19 and 20.—Two stages in the development of the subocular arch in Amblystoma, showing the rotation outward and back (from Winslow, 1898).

critical study of Winslow's work, however, convinces that the development of the arch in Amblystoma correctly interpreted is evidence against the hypothesis. The condition simulating the position of the parabasal process is an early condition predating the backward displacement of the lower jaw, and a stage of development corresponding to

Rana at the stage shown in figure 11. Now observe: although not attached to the ethmoid and occurring in a form with a much shortened metapterygoid process, when the backward displacement of the articulation does take place with its attendant change in the direction of the metapterygoid process, the palato-pterygoid process shares in the rotational movement and comes to be directed outward, downward and forward from the outer end of the metapterygoid process proximal to the articular portion thereof.

It is to be concluded that the attachment of the otic and parabasal processes to the cranium predated the backward displacement of the articulation and it was this fixation of the proximal end which caused the rotation of the metapterygoid process, and the point of fixation is the point about which the rotation took place.

In the Reptilia the parabasal process springs from the point of attachment. The approximation of the palato-pterygoid process of Ambylstoma to the same point, due to shortening of the metapterygoid, serves to emphasise the fact that, though the jaw has undergone backward displacement in the adult of both, whilst the true palato-pterygoid shares the attendant rotational movement, the parabasal process does not. The parabasal process is, therefore, not homologous with the palato-pterygoid process. It would seem then that this process is not homologous with the palato-pterygoid, hence the proposed new term parabasal.*

If the parabasal process be not homologous with the palato-pterygoid, then either:—(1) It is homologous with

*The term "parabasal process" is used throughout this section as though it had not already been applied to that with which in the discussion it is homologised. This has been done to avoid the duplication of terms or use of qualifying phrases to prevent ambiguity.

the metapterygoid process, or (2) it is a development of some portion thereof, or (3) it is an entirely new structure not represented in the Ichthyopsida.

1. It is notewothy that if the metapterygoid process of almost any amphibian, *e.g.*, Rana, as shown in figure 21 (outline from W.K.P., 1871, pl. ix.) be bodily moved forward and slightly inward, it would come to occupy the situation of the parabasal process and the articular end would be situated where the reptilian quadrate is. At first sight this appeared a satisfactory explanation, but it was discarded because it involved the assumptions that such a shifting was probable, that the proximal end was freed from its attachment to the skull and that a new attachment was developed.

2. Parker's figure 3, plate 7 (l.c.) reproduced (fig. 22), offers two suggestions in explanation of the problem before us. Firstly, the parabasal process is the homologue of the orbitar process. This, however, will be discarded at once, when it is remembered that the orbitar process is really a transient para-orbital phlange of very special development, and undergoes complete absorption very rapidly after it is removed by growth from the border of the orbit.

3. The second suggestion is, however, more fruitful. It is that the parabasal process is a development of that slip of cartilage in front of and below the prootic foramen which Parker terms the pedicle. Reference to an earlier stage (W. K. P., l.c., fig. 1, pl. v.) (fig. 23), reveals that
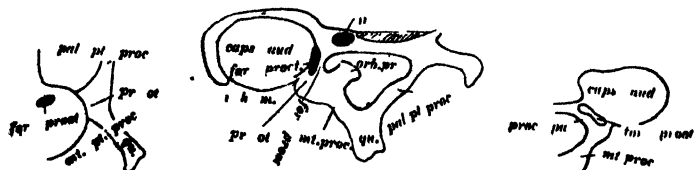
Figures 21, 22 and 23.—Three drawings showing features in the development of the subocular arch in Rana (from Parker, 1871).

pedicle extending forward in just the position relative to the skull and foramen prooticum occupied by the para-basal process of the reptiles. As development proceeds the "pedicle" becomes converted into fibrous tissue and the suspensorium becomes fused to the "supero-lateral edge of the auditory capsule" by the "secondary otic process." In this connection compare now figures 4, 5, 14 to 17, and figure 22.

In Amblystoma the "pedicle" (see figs. 19 and 20) is clearly recognisable; Winslow (l.c.) terms it the ascending process. In Amphiuma it is developed to a much greater extent, and is also clearly recognisable in Desmognathus. This pedicle of the metapterygoid process of the subocular arch arises from the inner end of that process near the ventro-anterior limit of its attachment, and extends thence forward and inward parallel to the base of the neuro-cranium below and in front of the foramen prooticum. It is crossed superiorly by the first branch of the fifth nerve and the palatine branch of the seventh, whilst the second and third branches of the fifth pass laterally and backward above its attachment to the metapterygoid. It may end freely anteriorly (*Ichthyophis glutinosus*).

The above description of the pedicle in the amphibians describes quite correctly in general terms the parabasal process of the reptiles.

There is no reason why this remarkable similarity should be regarded as a mere coincidence, and we are justified in regarding the parabasal processes of the reptilian quad-rate as homologous with the pedicle of the amphibian metapterygoid process.

VII. The Subocular Arch in Birds.

In the development of the fowl W. K. Parker (1869) described a palato-pterygoid tract and·a quadrate which was segmented from the proximal end of the tract from

which Meckel's cartilage is developed. Quite soon, how-
ever, the palato-pterygoid rod developed in the "(inner)
palatine region of the maxillo-palatine process" comes to
lie in the "walls of the cleft palate." That is to say it
is medial to the orbit. Meanwhile the quadrate, with
which it is never in continuity, has become "a very definite
triradiate cartilage; its antero-internal (orbital) process
passes under the trigeminal nerve, but does not reach the
cranial wall."

I have reproduced two drawings from T. J. Parker's
work on the development of Apteryx (1891), and placed
alongside the second a section of a similar region in *Emys
lutaria* (Kunkel, l.c.) embryo for comparison (figs. 24
to 26).*
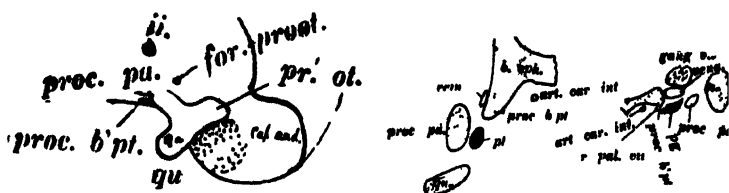
Figure 24.—The subocular arch and related portion of the
chondrocranium of Apteryx (from T. J. Parker, 1891).
Figure 25.—A section through the head of a young Apteryx
showing the relation of the pterygoid bone to the parabasal
process (from T. J. Parker, 1891).
Figure 26.—A similar section through the head of Emys
lutaria (from Kunkel, 1912). One of the sections shows the
right half, the other the left half.

It needs no further discussion to establish what is here
illustrated: the orbital processes of the birds is the homo-
logue of the parabasal processes in the reptile.

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*Parker's descriptions and his other drawings and sections
show that in the reconstruction (fig. 24) both the orbital process
and foramen prooticum are placed too high. His section does
not show the internal carotid artery. From a section further
forward I conclude its position is as indicated. Unfortunately,
the situation of the palatine ramus of the seventh nerve is not
given.

In the little sketch of the side view of Apteryx the epipterygoid process is all that is wanting to complete the resemblance to the condition in the reptile.

For the purposes of a later section it is here emphasised that the orbital process ossifies as such, and the pterygoid bone is developed quite independently of it.

VIII. The Subocular Arch in the Mammalia.

It were quite beyond the scope of the present discussion to examine the arguments relative to the various hypotheses surrounding the auditory ossicles and annulus tympani, and since our attention is at present directed towards the elucidation of the homology of the reptilian pterygoid bones with bones in the Ichthyopsida on the one hand and Mammalia on the other, it suffices here to note that in the mammalia the posterior elements of the subocular arch are represented by one or other of the bones of the middle ear, and there is no cartilaginous process or nodule relative to the development of the mammalian pterygoid which has been homologised with any part of the sub-ocular arch.

IX. Summary of the Facts in Relation to the Evolution of the Subocular Arch.

The most primitive, and at the same time nearly the most complete subocular arch is developed in the cyclostome fishes.

The selachians present a specialised reduction of the arch; the metapterygoid process is never well developed and is rapidly evanescent.

The Teleostomi develop a subocular arch wherein the palato-pterygoid, quadrate and metapterygoid are satisfactorily recognisable, but in the absence of any attachment to the skull, otic and parabasal processes are not developed except perhaps in Lepidosteus.

In the amphibia the whole of the structures present in the cyclostomes are reproduced in early stages of develop-

ment with remarkable faithfulness to type, and in addition, in later stages of growth, otic and basal processes are developed.

In the reptiles the palato-pterygoid process fails to develop, whilst the parabasal process reaches its maximum and in addition bears an epipterygoid process; the metapterygoid process is short.

In the birds the arch is still further reduced inasmuch as that the parabasal process is not so well developed as in the reptiles.

In the Mammalia the quadrate is present as one of the bones of the middle ear, and the pterygoid bone is developed quite independently of any cartilaginous structure definitely referable to the subocular arch.

Conclusion:

The parabasal process is not homologous with the palato-pterygoid or metapterygoid processes.

Corollary:

None of the bones developed in relation to the palato-pterygoid and/or metapterygoid process is *ipso facto* homologous with any bone developed in relation to the parabasal process.[*]

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[*]Whilst refreshing my memory of Parker's work on the crocodile skull (1885) I found the following extremely interesting passage which had totally escaped my notice on the previous reading . . . "The quadrate or mandibular pier is very large, and its main part is crescentic, hooking in falcate manner over the first cleft and the hyoid arch, along the forepart of the auditory capsule. The hinder, concave, bevelled edge is already forming the front boundary of the tympanic cavity; its lower end is the solid rounded condyle for the lower jaw; but its front margin is developed into a thin and somewhat bilobate process; this is the 'orbital process' so familiar to us in chelonians and birds; it is the common rudiment of the 'pedicle' (or) 'ascending process' and 'pterygoid cartilage'; the falcate postero-superior part of the quadrate is the otic process . . . ." (pp. 271-2).

I believe that this is the first statement of the correct homology of the parabasal process, but marred by the inclusion of pterygoid cartilage.

4. The Metapterygoid of the Teleost, the Pterygoid of the Frog, and Ectopterygoid of the Reptile are Homologous Bones.

The metapterygoid is developed as an ectochondral lamina (be it noted, not as a true replacing bone endochondrally) in relation to the metapterygoid process in the teleosteans. Examples in illustration of this fact might be multiplied; one only is selected—the early stages of *Salmo salar* (W.K.P., 1874) (fig. 27).
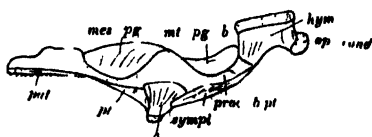
Figure 27.—Upper jaw of young Salmo (from W. K. Parker, 1874).

Though often confined to the region above and behind the quadrate, the resulting bone commonly extends forward to appear on the inner side of the quadrate in front of its anterior limit.

The adult relation to a persistent cartilage is well shown by Allis (1897) in *Amia calva* (fig. 28).

Figure 28.—Upper jaw of Amia calva (from Allis, 1897).

In the Amphibia the pterygoid bone typically first appears in relation to the junction of the metapterygoid process and palato-quadrate, extending as it develops both forward and backward. This is not a situation in which either a meso-pterygoid or pterygoid (teleostean) could develop. The teleostean pterygoid is developed entirely anteriorly to the quadrate on the lower and outer face

of the palato-quadrate; clearly then it is not homologous
with a bone developed on the inner face of the cartilage
proximal to the quadrate. The meso-pterygoid is certainly
developed on the inner face of the cartilage, but the adult
bone never comes to extend above the quadrate.

In *Lepidosteus osseus* the metapterygoid comes to articu-
late with the side of the cranium (Parker, 1882) (fig. 29).
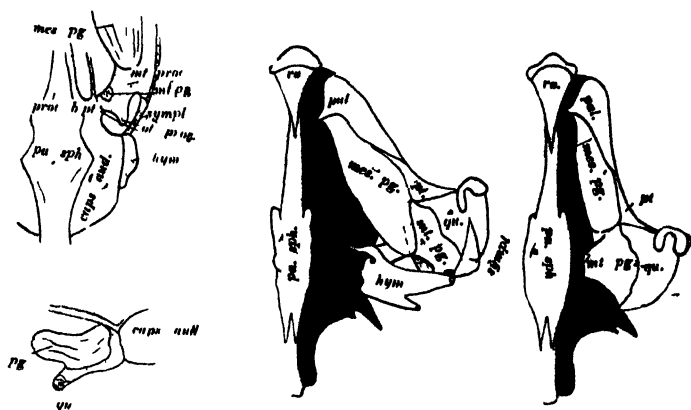
Figure 29.—Portion of the skull of a young Lepidosteus
(from W. K. Parker, 1882).

Figure 30.—Portion of the skull of a young Triton (from
W. K. Parker, 1885 bis).

Figure 31.—Palatal aspect of the right half of Promicrops
skull (original).

Figure 32.—A schematic modification of the last.

Now comparing the condition in these forms with that
in Triton (fig. 30) (W.K.P., 1885 bis) and other Amphibia,
one is constrained to admit (remembering that amongst
the Urodeles the condition in Triton is common) that if
any of the three pterygoid bones of the bony fishes is
represented by the pterygoid of the amphibia, it is almost
certainly the most posterior of the three, namely the meta-
pterygoid.

In this same connection I have drawn the palate of Promicops and placed alongside of it a drawing showing the same palate but with the hyomandibular and sympletic bones removed, and the quadrate and metapterygoid in contact with the side of the cranium (figs. 31 and 32). In this hypothetical drawing it will be seen that the position of the metapterygoid is essentially that of the pterygoid in the urodele Amphibia.

Lest doubt should later arise, it were well now to compare the pterygoid of Ichthyophis with the anterior arm and body of that in Branchiosaurus, there can be no doubt as to the homology of the structures. Similarly, comparison of the pterygoid of Cryptobranchus with the posterior arm and body of Branchiosaurus must also convince one of the complete identity of the structures (figs. 33, 34 and 35) (Kesteven, 1919).
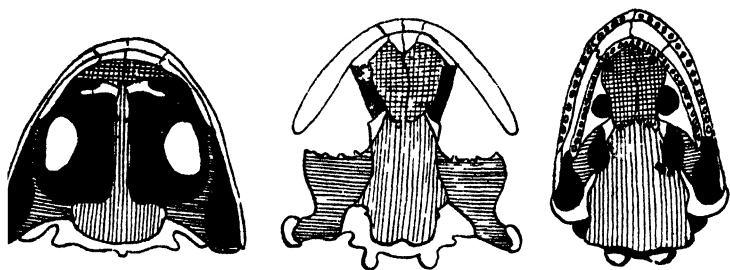
Figure 33.—Palatal aspect of the skull of Branchiosaurus (from Kesteven, 1919, after others).
Figure 34.—Palatal aspect of the skull of Cryptobranchus (from Kesteven, 1919, after others).
Figure 35.—Palatal aspect of the skull of Ichthyophis (from Kesteven, 1919, after others).

Having then convinced ourselves that notwithstanding its variations in position it is always the same bones which have been termed pterygoid in the amphibia (excluding the labyrinthodonts): the fact that these bones are not always developed in close association with the subocular

arch calls for some explanation consonant with the fact
of their homology.

In the axolotl (Parker and Bettany, 1877) pterygoid
osteogenetic tissue appears well forward in the situation
where, were a complete subocular arch present, that
chondral bar would be. This tissue develops a complete
osseous subocular bar, the anterior portion of which is
subsequently absorbed. We may be permitted to explain
this phenomenon on the assumption that the osteogenetic
tissue obeys a phyletic impulse. It is, however, extremely
interesting and significant that a bone whose homology
is in no way in doubt should in its early development
be divorced from the chondral anlage in relation to which
in other forms, and typically, it is developed. It is
probable that the pterygoid of Ichthyophis glutinosus is
developed in no closer relationship to the palato-pterygoid
cartilage than is the case with Amblystoma, or that it is
developed in relation to one of the isolated cartilaginous
nodules which constitute the anterior tip of the palato-
pterygoid process (Peter, 1898).

Turning next to the reptiles, we are met at the outset
with the fact that there is here no palato-pterygoid carti-
lage, a metapterygoid cartilage is present, and two bones
call for consideration in a quest for the homologue of the
amphibian pterygoid. Before, however, approaching that
subject, it were well to quest further back to the osseous
fishes, and at once the fact that the pterygoid (teleostean)
and mesopterygoid are developed in relation to the palato-
quadrate, places these beyond doubt out of court. If any
of the three teleostean bones is present in the reptile it
must be the metapterygoid, since that alone is developed in
relation to the portion of the subocular arch which is
persistent in the reptilian complex, namely the metaptery-
goid process. This is of course assuming community of
inheritance for the bones in reptiles and fishes.

Therefore, if subsequently it be shown that the amphibian pterygoid is the homologue of any bone in the reptilian skull, that becomes an added reason for regarding the amphibian pterygoid as the homologue of the teleostean metapterygoid.

In the reptiles it will be granted that the amphibian pterygoid is represented either by the pterygoid or by the ectopterygoid.

I have already (Kesteven, 1916, 1919) advanced cogent reasons for regarding the reptilian pterygoids as together homologous with the amphibian parasphenoid. In the next section it is, I believe, fairly conclusively proven that the reptilian, avian and mammalian pterygoids are absolutely homologous structures.

Now, the avian pterygoids are developed independently of any cartilaginous precursor; therefore, whether it be argued that the reptilian pterygoid or ectopterygoid is the homologue of the amphibian pterygoid, on following the bones into the Aves or Mammalia it becomes necessary to admit that bones which are homologous are developed in the one class in relation to cartilaginous precursory structures and in the other quite independently thereof.

In extension of the last statement. Assuming that the ecto-pterygoid is the homologue of the amphibian pterygoid, then one is forced to admit that in the reptiles the bone is divorced from its cartilaginous anlage. Contrariwise, let it be granted that amphibian and reptilian pterygoids are homologous, and continuing to trace the reptilian pterygoid and assuming that it has primary relation to the parabasal process (and in order that the reptilian pterygoid may be recognised as the homologue of the amphibian pterygoid, one is involved in the further assumption that the parabasal process is the homologue of the amphibian

palato-pterygoid process), one is next compelled to admit that it is homológous with the avian pterygoid, and to admit further that here again in the last, the bone is divorced from its cartilaginous anlage.

Since sooner or later one is faced with this difficulty under both hypotheses, one may be permitted to disregard it and endeavour to determine the question by other evidence.

This one does the more contentedly, already knowing that this divorcement does not contraindicate the homology of the bones as previously illustrated in the case of Branchiosaurus, Amblystoma, and Cryptobranchus and possibly Ichthyophis.

I have now to offer side by side two outlined tracings from W. K. Parker's work, and below them two reproductions from my own previous contribution.

It will be seen that the ectopterygoid of Crocodilus (W.K.P., 1885) (Fig. 36) develops in almost precisely the same position as the pterygoid in Siredon (W.K.P., 1887) (Fig. 37). There is, however, no palato-pterygoid cartilage and the jugal is more closely approximated than is the case in amphibia (e.g., Rana), where the metapterygoid
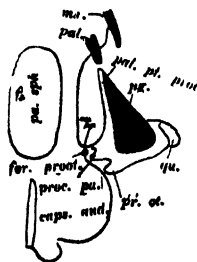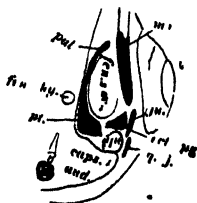
Figure 36.—Portion of the skull of a young Crocodile (from Parker, 1885).

Figure 37.—Portion of the skull of a young Siredon (from Parker, 1887).

process is longer and the palato-pterygoid cartilage intervenes. It will be noted that, were the quadrate in Siredon rotated back as in Crocodilus (and as occurs later in development in Siredon itself), the similarity would be more striking.

I have previously (Kesteven, l.c.) drawn attention to all the similarities in situation and relationship of the adult bones, as shown in the other two drawings (Figs. 38, 39).

In Lacertilia the ectopterygoid is found in the embryo (Fig. 40) (Gaupp, 1900) occupying just the position of the anterior portion which becomes absorbed in Amblystoma and Siredon, etc.

We conclude, therefore, that the metapterygoid bone of the osseous fishes, the pterygoid of the amphibians and the ectopterygoid of the reptiles are homologous bones.
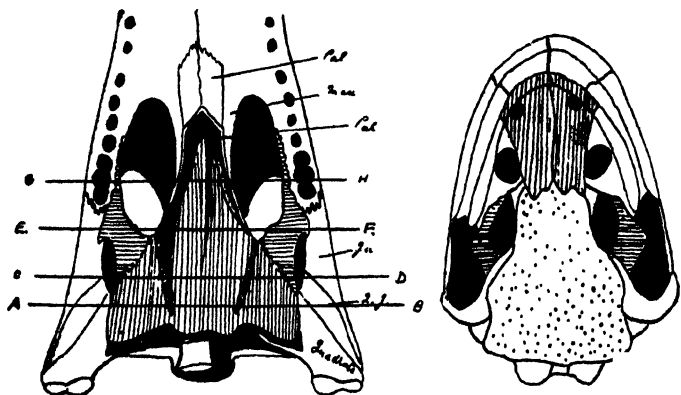
Figure 38.—Palatal aspect of the skull of the Crocodile, portion of the pterygoid and palatine bones removed (from Kesteven, 1919).

Figure 39.—Palatal aspect of the skull of Ichthyophis (from Broom, 1896).

Against this contention the most weighty argument is probably that in the two former cases the bones are

developed in direct relation to the metapterygoid process
of the subocular arch, whilst in the last no such direct
relationship can be shown.

Figure 40.—Portion of the palatal aspect of the skull of a
young Lacerta (from Gaupp, 1900).

Yet this argument, as already stated, if insisted upon,
must involve its own negation if the only alternative bone,
the reptilian pterygoid, be substituted in the serial homo-
logy for the ectopterygoid.

It further involves us in the assumption that all the
relationships of the parabasal process of the Reptiles and
Amphibia are mere coincidental resemblances, and the so-
called pterygoid process of the reptiles is really the meta-
pterygoid process of the Ichthyopsida.

Finally, it calls for an explanation of the following
(Kesteven, 1916, p. 304-305) :—

"Comparing the ectopterygoid of the crocodile with the
pterygoid of *Rana* it will be found that the following hold
true in both cases:—

1. The bones are on the postero-lateral border of the
   infra-orbital region.

2. They are triradiate.

3. The anterior ramus is related to the maxilla, and to
   the palatine bone *laterally* with respect to the orbit.

4. The postero-lateral ramus is related to the quadrate or quadrato-jugal (*i.e.* to the maxillary arch posteriorly).

5. The postero-medial ramus is related to the parasphenoid (pterygoid of authors, in the Reptiles).

6. Neither of these ever presents the median relation to the palatines and choanæ so constantly seen in the reptilian paired parasphenoids (pterygoids).

7. They form a bony bar over which the muscles of mastication work, and which separates the temporal fossa from the orbit.

"Once again, if these bones are not homologous then there has been a truly remarkable analogous replacement."

5. The Pterygoid Bone in the Reptiles, Birds and Mammals.
(a) Gaupp's Contention to the Contrary.

The most important contributions to the question of the homologies of these bones that I am acquainted with are from the pen of Gaupp (1905, 1910). Gaupp homologises the mammalian pterygoid with the crus transversum basisphenoidei of the lacertilians. Towards this view he tells us he was inclined while studying the development of Lacerta, but was convinced of its correctness when he found the "Säugerpterygoid" under the palatine bone of Echidna. . . . "Thus Echidna has on each side two bones which can lay claim to the name of 'Pterygoid'; an anterior one in a somewhat obscured position which corresponds to the pterygoid of other mammals (medial lamella of the wing process of the alisphenoid), and a posterior one which has always been regarded as the pterygoid of Echidna ('Echidna-pterygoid') corresponding to the reptilian pterygoid." . . . This leads him by comparison "per exclusionem" to the crus transversum parasphenoidei. ⋅

I have recently shown (1918) that without reasonable doubt the "Echidna-pterygoid" is really the alisphenoid,

being led to that conclusion by Watson, who, however, had failed to realise the importance of the suggestion which led me to that conclusion.

Gaupp does not rely only on the presence of two ptery-goids in Echidna for the proof of his hypothesis, but so important are they to his contention that his discussion leads constantly back to them in order to clinch many of his various arguments. The demonstration that there is but one pterygoid on each side amounts almost to a refuta-tion of his argument by the destruction of his primary premise.*

Finding it necessary to search in the reptiles for an homologue other than the pterygoid (which, as already stated, he regarded as demonstrably homologous with the echidna-pterygoid) for the mammalian pterygoid, he found it in the crus transversum parasphenoidei. To permit of such an homology he states that it is only necessary to assume that the lateral portions of the crus transversum have become independent, and that they have been displaced in a costal direction. The former assumption appears per-missible, for he states the lateral portions do arise inde-pendently of the crus longitudinalis in Lacerta and Anguis.

The second assumption, however, is totally lacking in precedent and involves a transposition so considerable that one may be permitted to doubt its possibility. In the Amphibia the lateral portions of the crus transversum are applied ventrally to the parotic region, and the centre of the crus lies behind the pituitary fossa. In Lacerta the centre of the crus lies beneath the pituitary fossa, and the lateral

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*In a contribution on the "Homologies of the Alisphenoids of the Sauropsida," Mr. E. Phelp Allis, Jr. (1919) challenges my interpretation of the echidna pterygoid. His contribution seems to give overwhelmingly too much value to relations to the trigeminal ganglion and nerves and far too little to the many anatomical and embryological factors which should be considered in a question of this kind.

portions are applied to the parachordal cartilage on either side of the basicranial fontanelle in front of its centre.

Moreover, Broom (1896) has advanced arguments which amount to a satisfactory demonstration that the reptilian parasphenoid as in Lacerta is the homologue of the mammalian vomer. This bone cannot be homologous with both the pterygoids and the vomer in Echidna.

Before leaving the subject it is permissible to remark that the recognition of "centres of ossification" (involved in the statement that the lateral portions arise independently of the crus longitudinalis) in a bone so minute and in which these "centres" fuse completely with extreme rapidity, seems somewhat in the nature of splitting straws. In all those bones which develop from a single centre there are always at the first scattered groups of osteoblasts whose activity sooner or later leads to the development of a centre of ossification.

It is to be further noted in this connection that in the stage which Gaupp figures, minute though the bone still is, "the parasphenoid is no longer separated from the basisphenoid in all its parts: growth has already taken place between it and the perichondrial basisphenoidal bone lamella." One would beg leave to doubt their separate identity.

Gaupp states that "the non-mammalian pterygoid originally has relations only with the pars palatina of the palato-pterygoid." That is to say, with the palato-pterygoid portion of the subocular arch. This statement applies only to the Amphibia and fishes and is one of the most important reasons advanced in the previous pages for regarding the reptilian ectopterygoid as the homologue of the amphibian pterygoid and against recognising as homologous the reptilian and amphibian pterygoid, so that his further statement—"the pterygoid of the mammals lies consistently at the base of the neural cranium"—becomes,

as it will be shown later, an argument for the complete homology of mammalian and reptilian as well as avian pterygoids.

The whole of Gaupp's arguments relative to the development of the processus basipterygoideus and its relation to the reptilian pterygoid fail in their application in view of what is stated in the last paragraph, and serve only to emphasise the consistent relation of the reptilian pterygoid to the base of the neural cranium. It appears that for some reason or other, no matter how far these bones be thrust from the median line, they maintain a relation with the basisphenoid.

I have already previously shown (1919) and palæontologists agree, that the palæontological evidence indicates a median situation as primitive for the reptilian pterygoid bones.

Turning next to the question of the vidian canal. In the human subject this canal lies below the basisphenoid, bounded below by the inner wing of the pterygoid process of the alisphenoid (i.e., by the mammalian pterygoid), and this may be regarded as the typical condition in the Mammalia, but it is to be noted that, as Gaupp himself states, the nerve at times passes forward on the median face of the bone. In such cases, were the vomer expanded between the bones as in the human subject (where the facial axis has been shortened) the vidian nerve would lie under the lateral wing of the tuberosity of the vomer exactly as it lies under the lateral wing of the parasphenoid (vomer) of Lacerta. In this connection it would be of interest to know the course of the nerve in the cetaceans.

It is to be noted that the relation of the "lateral wing of the parasphenoid" of Lacerta to the vidian nerve is, when correctly viewed, not so nearly like the condition in Echidna and the mammals generally as he maintains. In

Lacerta it is the outer lateral extremity of the bone which underlies the nerve, so that the bone is for the most part between the two nerves. In the mammals, which he claims to most nearly reproduce the same morphological relations, the nerve lies between the base of the pterygoid and the basisphenoid. The base of attachment of the pterygoid must be morphologically its median edge, so that the nerves lie for the most part between the bones.

Now, if one is to accept Gaupp's homologies, one must assume that the position of the nerve is variable or the bones have migrated from the centre line below the nerve till as in the rabbit (Krause, 1884, *fide* Gaupp), with Echidna as an intermediate stage (Gaupp l.c.), it lies wholly lateral to the nerve.

This is not quoted here as an objection to Gaupp's hypothesis, but because it is a difficulty which also lies in the way of my own contention that the reptilian pterygoid, lying lateral to the ramus palatinus nervi facialis, is the homologue of the lateral half or the crus transversum and main part of the crus longitudinalis of the ichthyopsidan parasphenoid lying medial to the nerve.

This matter will be returned to later; suffice it here to state that the relation of the nerve to the parasphenoid bone is demonstrably variable within the teleosts, as well as being variable to the pterygoids in the mammals.

(b) The Homology of these Bones in the Reptiles and Birds.

Though as far as my reading serves me, it is not explicitly stated, one may be permitted to assume that Gaupp was to a large extent led to the hypothesis we have been discussing by the fact that, whereas in the reptiles the pterygoids are very commonly developed in relation to condral precursal bars, in the Mammalia no such relation is consistently demonstrable. This fact calls for special emphasis, as it is a phenomenon quite unex-

plained under the old homology, more especially whilst the
reptilian pterygoid was regarded as homologous with the
amphibian pterygoid.

We have already seen that the last mentioned homology
is no longer tenable.

In *Emys lutaria,* Kunkel's wax model reconstruction
(1912) shows a developing pterygoid which is no more
nearly related to the parabasal process than it is to the
crista basipterygoidea, and his sections verify his model.

In Crocodilus, Parker (1835) fails to mention any
relation between the pterygoid at its first appearance and
the parabasal process of the quadrate, and a study of his
description and excellent drawings cannot fail to con-
vince one that this was not an oversight, that no such
relationship ever exists. A comparison of his figures viii
pl. 65 and vii pl. 67 serves to clinch the matter. The para-
basal process is well developed, as seen in the side view
of the skull, and extends forward beyond and below the
pituitary fossa in the typical situation. The pterygoid at
the hinder portion of the pituitary fossa is seen in the
section (Fig. 41) developing in relation to the cartilaginous

Figure 41.—Section through the head of Crocodile, in the
region of the hypophysis (from Parker, 1835).

crista basipterygoidea; why the parabasal process is not
shown is not clear: possibly the embryo was a little further
advanced than the specimen dissected, and the process had
aborted.

In Sphenodon on the other hand, Howes and Swinnerton
demonstrate quite clearly the first centre of ossification of
the pterygoid in relation to the parabasal process.

Amongst the reptiles we find then that the pterygoid may (chelonians and crocodilians) or may not (lacertilians, ophidians and Sphenodon) be developed independently of a precursory chondral bar.

In the birds it is agreed that the orbital process of quadrate is the homologue of the parabasal process in the reptiles.

The orbital process of the avian quadrate persists and is directly ossified endochondrally as such, and the pterygoid is developed entirely as a membrane bone. . . . "The identity in mode of development between the palatine and pterygoid and the remaining membrane bones is illustrated by fig. 117, in which the rudiments of the quadrato-jugal (Qu.Ju.) and pterygoid (Ptg.) are seen to be of precisely similar character." (T. J. Parker, 1891, p. 63). This being so, it is necessary to satisfy ourselves as to the homologies of the avian pterygoids before proceeding further.

Although this is not a matter that calls for much discussion, since as far as I am aware the homology of reptilian and avian pterygoids has never been questioned, a brief examination of the morphological relationships will be pertinent if only to close the argument.

In 1910 I published (Kesteven, 1910) a detailed description of the bones of the skull of *Chelone midas,* and I then expressed the opinion at the conclusion of the description of the quadrate that—"The otic and suspensory rami and pedicle are completely homologous with these three portions of the amphibian suspensorium." A study of W. K. Parker's (1880) report on the development of *Chelone viridis (seu midas)* confirms that opinion. Portion of the orbital process is ossified to form what I then termed the pedicle, and *with this ·the epipterygoid articulates.*

In Chelone then, there is an osseous orbital process present as in the birds.

With the last fact established, I have to offer for comparative examination, three drawings: the first is reproduced with added lettering from my own paper on the "Pterygoid in the Amphibia and Reptiles and the Parasphenoid" (1918); the second is a perfectly legitimate modification of the first, wherein the pterygoid bones have been reduced to narrow rods, the basicranial structures exposed between them, and a basipterygoid process added; the third is traced from T. J. Parker's paper on Apteryx quoted above (1891). With these drawings I leave the subject, believing that the homology of reptilian and avian pterygoids, never seriously questioned, is satisfactorily demonstrated beyond further questioning (Figs. 42, 43 and 44).
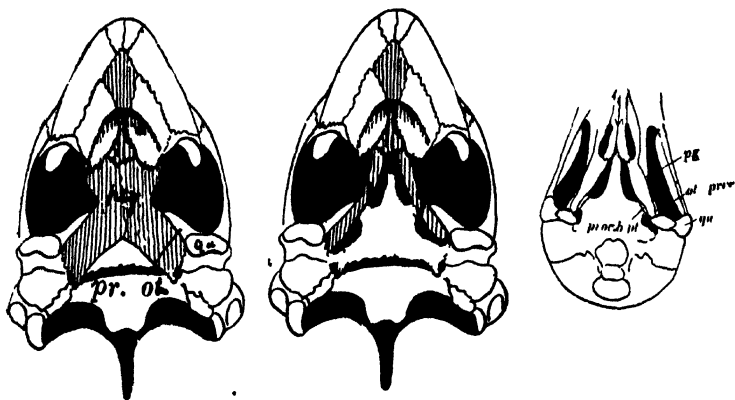
Figure 42.—Palatal aspect of the skull of Chelone midas (seu viridis) (from Kesteven, 1910).

Figure 43.—A schematic modification of the last.

Figure 44.—Palatal aspect of the skull of Apteryx (from T. J. Parker, 1891).

It is now to be emphasised that in the reptiles the pterygoids may or may not, but mostly do, first appear as ectosteal lammiæ in relation to the parabasal process, whilst in the birds the same bones never develop in that manner.

The absence of a cartilaginous precursor (referable to the parabasal process) to the mammalian pterygoids does not, therefore, constitute an insuperable objection to homologising those bones with the reptilian pterygoids.

As a matter of fact, however, the invariable absence of a cartilaginous precursor to the mammalian pterygoid which has been assumed heretofore for the purposes of argument is not an assumption consonant with the facts, and it is even arguable that the cartilage associated with the early development of the pterygoid in certain mammals is homologous with portions at least of the parabasal process.

Gaupp states that Fawcett in 1905 described the hamulus of the human pterygoid as being developed from cartilage and that "Preformation of the pterygoids in cartilage is found by Wincza (1896) in *Erinaceus europœvs* by E. Fischer (1901, 1903) in *Talpa europœa, Macacus cyno-molgus, Semnopithecus maurus,* and that he can confirm it in *Mus musculus.*" It therefore occurs in both primitive Talpa and highly-developed mammals.

Compare with this the fact that in several reptiles, Lacerta (Gaupp, 1910) and Agama and Chamaeleo (Broom, 1903), the anterior portion of the parabasal process is divorced from the quadrate, and the pterygoid develops in relation to it, and we have the basis of our argument in favour of the homology of the cartilaginous precursor of the pterygoids (see Fig. 18 *antea*) in the two classes.

(c) **Transverse Sections through Similar Regions of Various Sauropsid and Mammalian Heads and Apteryx.**

So many arguments against the homology of the mammalian and reptilian pterygoids have now been shown to

be without real weight that it is hardly necessary to detail facts of morphological relations in favour of the homology.

Rather than run the risk of wearying my readers by the recapitulation of facts of comparative anatomy and osteology with which they must be already fully familiar, I offer for comparative study a series of outline tracings of transverse sections of various mammals, reptiles and of Apteryx (Figs. 45 to 49), being satisfied that the juxta-
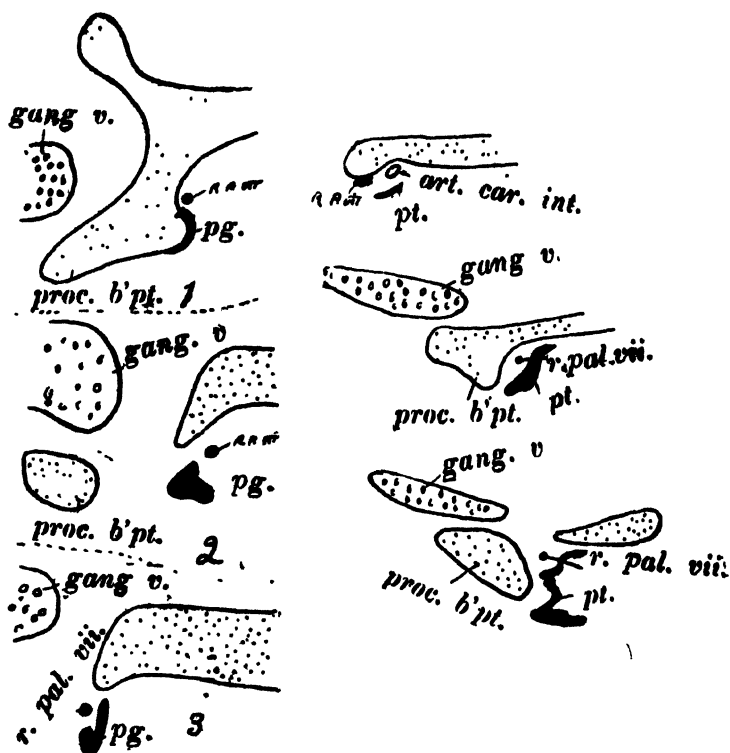
Figure 45.—Three sections through the basisphenoid and pterygoid of Echidna (from Gaupp, 1910).

Figure 46.—Similar sections through the head of Perameles (from Gaupp, 1910).

position of these drawings presents a case in favour of the homology of the bones in the three classes so strong as to be practically irrefutable.
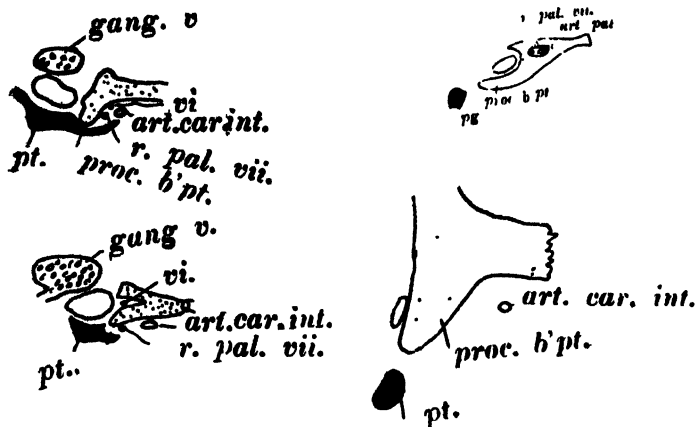
Figure 47.—Similar sections through the head of Emys lutaria (from Kunkel, 1912).

Figure 48.—Similar section through the head of Delma (original).

Figure 49.—Similar section through the head of Apteryx (from T. J. Parker, 1891).

6. The Mammalian and Sauropsidan Pterygoid and the Ichthyopsidan Parasphenoid.

(a) Watson's Recent Criticism of this Thesis (1919).

Before entering on the discussion of this subject, it were well to briefly recapitulate the facts established in the previous sections. They are:—

(1) The parabasal process of the sauropsidan quadrate cartilage is homologous with the pedicle of the sub-ocular arch of the amphibia and cyclostomes, and not with the palatine or palato-pterygoid portion of that arch.

(2) The metapterygoid of the teleosts, the pterygoid of the amphibia and the ectopterygoid of the reptiles are homologous bones.

(3) As a corollary of both these conclusions, the ptery-
goid of the reptiles is not homologous with the
pterygoid of the amphibia.

(4) The pterygoid bones of the reptiles, birds and
mammals are homologous bones.

Of course, it is not claimed that the above conclusions
are proven; it is very keenly realised that none of these
questions are capable of proof. Complete proof of any
statement of development in biological science depends
upon the actual observation of the sequent stages in the
development, in questions of phylogenetic development
(this is, in the nature of the problem, impossible), and the
ultimate acceptance or rejection of any hypothesis put
forward depends largely on the personal equation in the
evaluation of evidence mainly, if not entirely, circum-
stantial.

It is, however, claimed with confidence that in the previous
pages the facts of development and morphological relation-
ship relative to the structures discussed, have been juxta-
posed in their correct form and without distortion, in such
a manner as to constitute a satisfactory demonstration of
verity of the conclusion arrived at.

In opening this portion of my discussion 1 am led to
briefly review my last communication (Kesteven, 1919) by
the appearance of a criticism thereof which immediately
follows it from the pen of D. M. S. Watson (1919). He
claims that my thesis "is at once invalidated by the facts"
which he mentions. Those "facts" are that I have been
misled by Embleton and Atthey's erroneous account of
the palate of Loxomma. The choanae, he states, are not
far back as described, but situated in the small openings
lettered A.P. (on either side of the vomers). The median
ridge labelled R. is part of the parasphenoid, "which in
this amphibian is a long laterally compressed bone sheath-

ing the lower edge of the ossified orbital septum. The pterygoids are clearly separated throughout their length and articulate by definite surfaces with the basipterygoid processes which lie to either side of the reference line B.s.p.h. The bone labelled P.p.mx. is divided in two by a suture, the anterior part being the palatine, the posterior the ectopterygoid.'' Unfortunately I have not been able to obtain a copy of either this paper on Loxomma or his paper describing a series of labyrinthodonts, but I note with interest that he claims, and I have no doubt of the verity of his claims, to have described a series ''leading from this (Loxomma) type of palate to a typical labyrinthodont type with a large parasphenoid and large interpterygoid 'varieties' '' (vacuities?).

I stand corrected and note with interest also his statement that the Rana type of palate is not the commonest amongst the amphibia.

I must, however, join issue with.him when he contends that it is not the most primitive, for surely the largest parasphenoid must be the most primitive, since it approaches nearest to the teleostean condit'on, and its reduction in size in the Sauropsida a further advance along the same lines as in Loxomma.

Watson also states that Meek (reference not available) and Shiino (Anat. Hefte Bd. L. Hft. ii) have shown that there is a small median parasphenoid in the embryo Crocodilus in the usual reptilian position. I may add that Gaupp (1905) has also described this bone.

The condition of the parasphenoid in the ''Jurassic crocodile, Metriorhynchus'' is also quoted, and having found Leeds' and Andrews' papers, I shall deal with the condition later.

The presence of a large median parasphenoid in adult Dermochelys is also averred on the authority of Versluys.

That paper I have not found, but having Nicks' detailed description of this skull I am in a position to deal with the question.

Lastly it is noted that the vomer of chelonians is shown by its development to be a fused pair of prevomers. I have been unable to find the account on which this statement is made, but I had already noted the same statement in Watson's "comments" on the second report of the Committee on Nomenclature of the Cranial Elements in the Permian Tetrapods (1917), and have no reason to doubt that what he states is correct.

He concludes his brief dogmatic "Notes" as follows:— "There is, in fact, no doubt that the Loxomma palate, which greatly resembles that of the osteolepid fish, is the primitive Tetrapod type, that with only slight modification it leads directly into the reptilian palate and by increase in size of the interpterygoid varieties (vacuities?) and of the parasphenoid it passes into that characteristic of the amphibia, the whole process being shown in the Order Labyrinthodontia."

Now to anaylse these "facts" *seriatim*, commencing with the last. Among the Crossopterygii, which include osteolepid fishes, the only palates whose interpretation is beyond cavil are those of the recent species. That of Polypterus conforms in all respects with the normal teleostean palate. Of this there can be no doubt whatever. Watson's comparison then is with the whole of the teleostean palates (perhaps excepting the acipenserids and Lepidosteus). In these, as indeed in Polypterus itself, the parasphenoid is very large and presents the crus transversum which, however, owing to the impaction of the auditory capsules into the side wall of the cranium, extends upward instead of laterally, as becomes the case when the increase of the capsule leads to the development of the parotic processes, at the same level as the cranial base.

With the assertion that the Loxomma palate, with only slight modification, leads directly into the reptilian palate, I am in entire agreement; that was, and still is, my argument. The erroneous description did not mislead me in my conclusions, and I am pleased that Dr. Watson should agree with me in this respect.

We are at variance, however, in the interpretation of the modification.

The presence of median parasphenoid in the Loxomma palate between the pterygoids and extending back as far as, or nearly to the basi-pterygoid processes, does not in the least vitiate my arguments; such a reduced parasphenoid is present between the pterygoids in all reptiles, if not in adult then in embryo, the differences depending on the degree of reduction, and I have dealt with the condition in the reptiles.

I have already stated that I am in agreement with Broom, and indeed, if we may quote the report on nomenclature already referred to, with Watson himself in regarding the median portion of the parasphenoid which thus persists as the homologue of the mammalian vomer.

I was apparently at fault in assuming the absence of a true vomer in Crocodilus. I now reproduce my own cross sections of the choanal region of *C. johnsoni*, alongside those of Leeds (Figs. 50, 51 and 52) of the same region in Metriorhynchus to show that (if Leeds and Andrews be correct), as the vomer develops (from the anterior rudiment of the parasphenoid) it replaces the vomerine portion of the conjoint pterygoid in a truly absolute manner, from which one is justified in assuming that in *C. johnsoni* all three centres fuse to form the conjoint bone. (I have added the palatine bone to my other sections in outline; the original portion is solid black.)
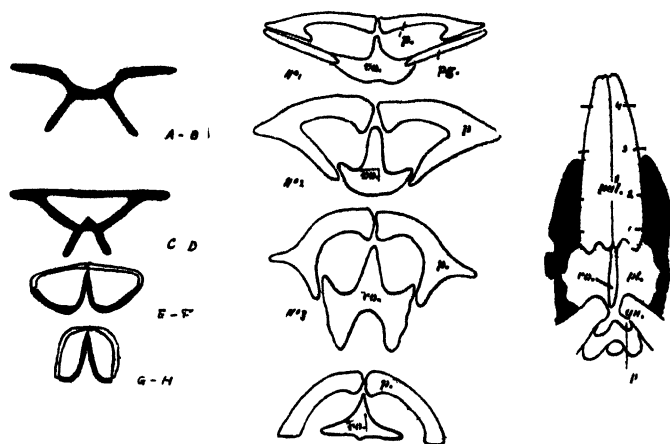
Figure 50.—Sections through the palatine and pterygoid of Crocodilus at the levels indicated in Fig. 37 (from Kesteven, 1919).

Figure 51.—Similar sections through Metriorhynchus (from Leeds, 1908).

Figure 52.—Portion of the palatal aspect of the skull of Metriorhynchus (from Leeds, 1908).

A reference to my paper will show that this replacement is exactly as I conceived it might take place. Were I not more anxious to avoid a well merited charge of special pleading, I might well lay claim to a remarkable clairvoyance, but I am loath to trust the interpretation of the Metriorhynchus palate, founded as it is on the "numerous fragments" in which the bones "were excavated" (Leeds, p. 353). I am confident that the palate has been misinterpreted. However, if herein 1 am wrong, then the thesis I defend is supported by the condition described in a truly remarkable manner. How Watson failed to realise this fact I am unable to understand.

The parasphenoid of Dermochelys is shown by Nick (1912) both in basal view and longitudinal section, but as Watson states, that which I had regarded as the vomer

in the chelonians is really prevomer; therefore, it follows, the chelonians are not a group apart as I assumed, but fall into line with the other reptiles, and the parasphenoid is again referable to the true vomer. Dermochelys is, I have found, peculiar among the chelonians in the size of the true vomer. This bone has been demonstrated in embryo in several forms. A similar error was made by Broom (1903), but leaves his vomerine theory of the parasphenoid similarly unaffected.

Watson is, however, emphatically wrong when he states that in "Crocodilus, as in all other reptiles, the pterygoids develop in association with the palato-quadrate cartilage." As I have already shown that cartilage is not present in any reptiles, and moreover, the bone does not even develop in relation to the parabasal process which has in the past been regarded as the homologue of the palato-quadrate.

Though Watson advances the presence of ectopterygoids in the labyrinthodont skull as an objection to my thesis, it may be pointed out that it is just as reasonable to interpret their anterior situation as being due to a migration forward from the situation of the pterygoid in amphibia as to trace them backward from the anterior situation in such forms as Loxomma and Pareiasaurus to their posterior situation in Ichthyophis and Crocodilus and batrachians. The former hypothesis is supported by the fact that always the ectopterygoid is situated where it could have developed in association with the palato-pterygoid or metapterygoid process, whilst the reptilian pterygoid never occupies such a position.

Watson, in the concluding paragraph of his "Notes," assumes the.median position of the pterygoids as primitive, and their lateral position in such forms as Rana as secondarily derived from the median position by increase of the interpterygoid vacuities, and the bones in both forms as homologous.

This is an assumption entirely at variance with the
known facts, for it is demonstrable beyond reasonable cavil
that the primitive position of the subocular arch was as
at present in the cyclostomes, teleosts and recent
amphibians, and that therefore the primitive situation of
bones related to that arch developmentally was also, as
in these forms, lateral, *not* medial.

Be it noted this is not in any sense a contention that
the median situation of the pterygoids, in whatsoever
found, is not the primitive condition or directly traceable
to a primitive condition. In this respect Dr. Watson and
I are in entire agreement. My contention is that they are
derived from a median parasphenoid, and that there are
no laterally placed pterygoids. Dr. Watson would say the
pterygoids are laterally placed, widely separated bones in
the fishes and most of the amphibians, but they are placed
close to the midline, often having a common median suture
in some amphibians, all reptiles, birds and mammals. In this
he is in accord with accepted teaching. Written baldly
as above it seems almost incongruous.

In order to put Watson's hypothesis on a basis consonant
with the facts of the evolution of the subocular arch, it
would have to be extended somewhat as follows:—In the
primitive tetrapod palate the subocular arch and its asso-
ciated bones had come to lie against the side of the skull
base. In the development of the palate of the Rana type
there has been a return to the primitive arch-vertebrate
condition. The parabasal condition of its ancestor, the
primitive tetrapod, being entirely dropped out of its onto-
genetic history, although both the cyclostome and teleostean
phases are clearly retained.

Such an extended statement of his hypothesis (which is
the only one which can in any way bring that hypothesis
into line with the facts of ontogeny and of phylogeny as

evidenced in the series of ontogenies) itself constitutes a refutation of and "at once invalidates" the hypothesis. It is apparent that the whole thing depends on the interpretation of the peculiar Loxomma type of palate and his labyrinthodont series, and is without one tittle of evidence in its support from any other direction.

(b) Instances of Zygous and Azygous Homologous Elements.

There is abundant evidence that there is nothing inherently objectionable in the hypothesis that a median bone in one form may be represented by completely homologous paired elements in another. Both parietals and frontals are described as azygous elements in some forms and as zygous elements in others, and regarded as homologous structures; examples are so numerous as to need no citation. Gaupp has contended that the true reptilian vomer (parasphenoid) ossifies from two centres, and is willing to recognise the paired mammalian pterygoids as homologous with this median bone. "In man the vomer arises as a pair of small elements below the nasal septum . . . . in most mammals . . . . it arises by a single centre" (Watson, 1917) and the homology of the bones within the mammals is not, so far as I am aware, in question. The basisphenoid ossifies from two centres in Crocodilus (Parker, 1885) from one in most reptiles, and from two in some mammals.

This being so, it were inconsistent to advance the dual nature of the reptilian pterygoids as a valid objection to regarding them as derived from the median ichthyopsidan parasphenoid.

(c) The Morphological Relationships of the Ramus Palatinus Nervi Facialis and the Internal Carotid Artery.

These are important morphological relationships which call for careful study.

In the amphibia the ramus palatinus nervi facialis comes to lie between the parasphenoid and the mucous

membrane of the palate. It attains this position by swing-
ing round the lateral edge of the bone in an antero-medial
direction after its emergence from the otic capsule. As
far as I am aware it never perforates the parasphenoid.
In the reptiles this nerve lies above the pterygoids in
those forms where they meet in the midline, and medial
to them when, as in Delma and Lacerta they (the bones)
are thrust asunder.

The internal carotid artery in young embryos of *Limno-
dynastes peronii* perforates the basal plate on either side
of the posterior limit of the hypophysis. No other struc-
ture passes through the cartilage with them, the palatine
branches of the facial nerve, here lying at a lower level
and farther from the midline. In young adult *Hyla aurea*
I find that the artery, which branches inside the cavity
on either side of the hypophysis, and which is therefore
the internal carotid, enters the cranial cavity below the
emerging roots of the seventh nerve without perforating
the parasphenoid. Whether it be the same vessel carried
outwards by the development of the medial portion of the
brain case floor, I have not the intermediate material to
decide.

As previously stated, in the Teleostomi the course of the
nerve is variable. Thus Allis (1897)—"The ramus pala-
tinus facialis arises from the ventral surface of the
trigemino-facial ganglion towards its median edge. It runs
downward and forward in the upper lateral chamber of
the eye muscle canal, and passing through the palatine
foramen, enters the palatine canal between the para-
sphenoid and the ventral surface of the cartilaginous
cranium" in *Amia calva*. Herrick (1899) says: "Stannius
states that in fishes which have a well-developed subcranial
canal ("Augenmuskel canal") the r. palatinus traverses
it on the way to the mouth. This certainly does not apply

in the case of Menidia. The subcranial canal is well developed, but the r. palatinus does not enter it, but run* along the outer side of the canal, not the inner, as Stannius describes in his types."

Regarding the reptilian pterygoids as the parasphenoid, the position of the nerve between them and the basisphenoid would therefore represent the condition present in Amia and the types described by Stannius.

Considered from the other point of view and assuming that the reptilian pterygoid is the amphibian, as in Rana, drawn towards the centre till it articulates with basisphenoid, as in chelonians. The pterygoid at its attachment in Rana to the metapterygoid process is on a morphologically higher plane than the foramen of exit of the facial nerve, so that as it, maintaining its posterior attachment, becomes drawn towards the centre, it should pass above the nerve, which, therefore, should in the Reptilia lie below, not above, the bone.

Of the internal carotid artery in *Amia calva,* Allis (l.c.p. 498) says: "The internal carotid artery enters the palatine canal between the parasphenoid and the basis cranii, and after crossing the palatine foramen, turns upward into the internal carotid canal and enters the cranial cavity under or median to and in front of, the optic nerve of its own side." His drawings, than which I know no better, indicate relations to the cranial elements and to the hypophysis of the artery and vein strongly recalling the relations demonstrated later in chelonia.

Gaupp (1905, 1910) has already shown that the course of the nerve is variable in the Mammalia, as previously quoted. 1 have now to point out that it is equally variable in the reptiles.

In Delma (Figs. 53, 57) I find that the ramus palatinus nervi facialis, after its emergence from the geniculate
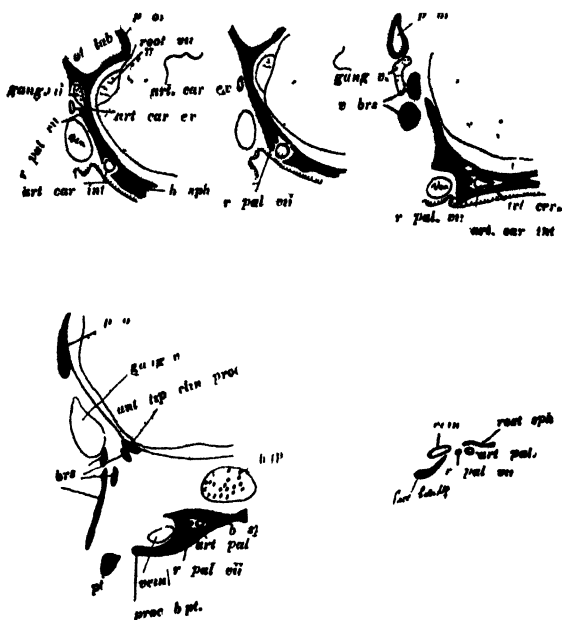
Figures 53 to 57.—Transverse sections through the head of Delma, showing the course of the r. palatini nerve vii. and the internal carotid, cerebral and palatine arteries (original).

ganglion in a fossa on the outer side of prootic (Fig. 53), immediately tunnels that bone downward, forward and medially to reach, at the articulation between the prootic and basisphenoid, a vessel which is certainly the internal carotid artery (Fig. 54). Immediately on the outer side of the prootic in this region there is a vein of considerable size which is probably the external jugular vein. The artery lies partly imbedded in the two bones, which articulate above it at the point where it is joined by the r. palatinus. The two structures lying side by side tunnel forward and medially through the substance of the basisphenoid, the artery lying always to the inner side of the nerve, and come to lie on either side of the midline in what

would appear to be Gaupp's parabasal canal. At the posterior limit of the pituitary body the artery divides into two branches; the cerebral artery passes towards the midline and upward through the bone to enter the brain cavity at the hinder level of the hypophysis, whilst the palatine continues forward to the inner side of the nerve exactly as the internal carotid does up to its branching. Figure 55 shows the structures just at the posterior commencement of the division of the artery.

At the transverse level of the basipterygoid process the nerve and palatine artery are found in the same situation with the vein lying in a groove on its upper surface (Fig. 56). Immediately in front of the process the artery lies under the rostrum basisphenoidei, the nerve alongside of it and the vein immediately to the outer side of this, the last being situated just above the anterior flange of the process (Fig. 57). Traced further forward, the three structures are to be found lying just above the mucous membrane of the roof of the mouth, to the inner side of the pterygoid bone. The division of the common carotid into internal and external lies at approximately the same horizontal level as the internal carotid, as shown in Fig. 53, but almost at the posterior limit of the otic capsule. The ramus palatinus gives off a branch caudad at the point where it first reaches the artery, or at that point receives a bundle of (sympathetic?) fibres which can be traced back above and somewhat to the inner side of the common carotid artery, their ultimate distribution (or (origin?) I have been unable to determine. The other main branches of the facial nerve arise direct from the ganglion in the fossa above described.

In Varanus I have determined by dissection an essentially similar course for the ramus palatinus, but have not determined the situation of the related blood-vessels.

In *Chelonia midas* (*seu Chelone viridis*) I find by dis-
section that the facial nerve issues from the antero-ventral
aspect of the prootic, and the ramus palatinus turns
forward along the under surface of the bone. I have
already drawn attention to the groove formed for the
reception of the branches of the nerve (Kesteven, 1910,
p. 379) as they pass back and forward. Crossing the
cartilaginous synchondrosis between prootic and basi-
sphenoid, the nerve passes forward and ventrally along the
inner wall of what (l.c.) I termed the jugular canal. It
thus comes to lie on the lateral surface of the basisphenoid
just below the post-clinoid eminence. The canalis abducen-
tis in the root of the post-clinoid process lies almost directly
above it, separated by the thickness of the basisphenoid.
Continuing forward and descending a little it lies against
the lateral surface of the rostrum basisphenoidei. At the
root of the rostrum it crosses the cerebral artery where that
enters the so-called parabasal canal to reach the cranial
cavity in the floor of the sella. The dissection from which
the above description is drawn was made several
years ago, and though the notes thereon are quite clear
as to the course of the nerve, they are ambiguous with
reference to the vessels. In the region of the emergence
of the branches of the facial nerve, that which I have
termed the jugular canal undoubtedly corresponds to
Gaupp's parabasal canal, if the contained structures may
be taken as determining the matter. In Chelone then, the
parabasal canal lies between the basisphenoid on the inner
side, the prootic above and the pterygoid bone below and
on the outer side. At its origin there can be no doubt
that the ramus palatinus lies above and to the outer side
of the internal carotid, which enters the canal along its
inner wall after having perforated the substance of the
"basitympanic" (Kesteven, l.c.) portion of the pterygoid.
A large vein, which is probably the same as that which

I have provisionally designated external jugular in Delma, enters the parabasal canal from its outer side behind. It is probable, then, that these relations are maintained at least to the anterior end of the rostrum basisphenoidei, the internal carotid giving place to the palatine artery in front of the point of this division. I have drawn a reconstruction of portion of a cross-section at the level of the root of the post-clinoid process (Fig. 58).
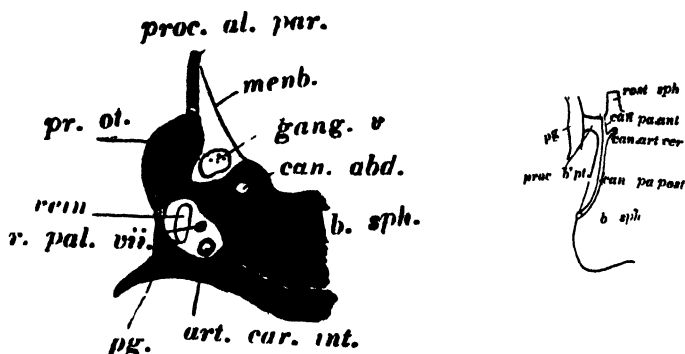
Figure 58.—A reconstruction of the canalis parabasalis and contained structures in Chelone midas (original).

Figure 59.—A schema of the parabasal canal and its branch (original).

Gaupp (l.c., 1905, 1910) describes the situation of the r. palatinus in Lacerta, and apparently it resembles closely the situation in Delma and Varanus. He states, however, that in the tortoises the canal contains only the arteria carotis interna; here, it seems, he falls into error.

I have schematically indicated above (Fig. 59) the canals in Delma. In the posterior portion (canalis parabasalis posterior) the arteria carotis interna runs forward alongside the r. palatinus. Just at the posterior limit of the sella and basi-pterygoid process, the canal branches and the cerebral artery (or carotis interna cerebralis) leaves

the nerve, which continues forward in the anterior portion
of the canal with the palatine artery, to its inner side.

Now a perusal of my description of the course of the
nerve and artery in Chelonia must at once convince that
it is the canalis arteriae cerebralis that transmits the carotid
artery just as in Delma, and that a true canalis parabasalis
is present in Chelonia between the parasphenoid and ptery-
goid.

Further, Gaupp is apparently in error when he claims
that the parabasal canal does not tunnel the substance of
the basisphenoid, for in Delma it enters that bone quite
behind what must have been the posterior limit of the
vomerine remnant of the parasphenoid. I have not seen
Siebenrock's paper (quoted by Gaupp), but it appears
probable that he correctly describes the branch of the
parabasal canal, which I have termed canalis arteriae
cerebralis.

Kunkel says (1912), "The ramus palatinus nervi facialis
arises from the lateral aspect of the ganglion facialis and
passes in a ventro-median direction round the free edge of
crista substapedialis and then turns in an anterior direc-
tion in the sulcus palatinus, which is medial to the rudi-
mentary processus basipterygoideus on the ventral side
of the basal plate. (His crista substapedialis is the lateral
margin of the basal plate where it underhangs the otic
capsule in the anterior and middle thirds thereof.) In his
Figure 20, reproduced (Fig. 46), the nerve is shown lying
on the inner side of the crista basipterygoidea with the
inner end of the os pterygoideus below it.

In parenthesis, Kunkel describes an os parasphenoideum
which appears only after all the other membrane bones
are well established. It commences as a tripartite bone,
the two lateral wings of which embrace the *stalk* of the
hypophysis at the same time as ossifications in cartilage,

and early become fused with the basisphenoid. One may remark in this connection that, embracing the stalk of the hypophysis, these are surely on a higher level than the true parasphenoid, which lies below the hypophysis, and their appearance in point of time along with the ossifications in cartilage is a significant coincidence.

Sufficient has now been described and quoted to demonstrate the variability in position of the ramus palatinus.

It is significant, however, that in the chelonians this nerve and the accompanying internal carotid artery lie between the basisphenoid and pterygoids in the same morphological situation as the nerve and artery between parasphenoid and cartilaginous cranium in the teleosts, and also in the same manner as further forward it lies between vomerine remnant of the parasphenoid and basisphenoid in the early embryo of Lacerta.

Having now carefully reviewed the course of the palatine nerve and the internal carotid artery in so far as my knowledge of the literature and my material enable me, I believe that, as the advocate of the hypothesis. I can be accused of nothing more than extreme moderation when I contend that these varying relationships do not in any way contra-indicate the homology of the Ichthyopsidan parasphenoid and sauropsidan and mammalian pterygoids.

7. The Development of the Reptilian Pterygoids in Relation to the Parabasal Process.

Writing the heading for this section of my paper I inadvertently wrote sauropsidan for reptilian; making the correction, I was at once struck with the truth that therein lay one of the most important facts in this connection:— The avian pterygoids are not developed in association with the parabasal process, and yet their homology with the reptilian pterygoids has gone, and probably will go, unchallenged.

We have also seen that without reasonable doubt the parabasal process of the quadrate in the two forms is homologous, and this also has gone unchallenged as far as I am aware.

How comes it then that bones undoubtedly homologous are commonly developed in one class only in association with a cartilaginous structure which is present in both?

Which of these two conditions is primitive and which is secondary?

The question is introduced here in order that it may be discussed in its bearing on the proposal to regard as homologous the amphibian parasphenoid and reptilian pterygoids.

It is thought that it may be contended that inasmuch as the reptilian pterygoids are commonly related to the parabasal process, whilst the amphibian parasphenoid is associated with the cranial basal plate, the two bones cannot be homologous. Such a contention is so apt that the matter calls for some examination in order that we may arrive at a decision as to its real value.

In the first place it may be pointed out that, *mutatis mutandis,* a difficulty of a very similar nature lies in the way of regarding as homologous the pterygoid bones of the birds and reptiles: one is and the other is not developed in association with a cartilaginous structure present in both, yet their homology *inter se* is not questioned.

Again, the palatine bone of the teleostean fish and some amphibia is developed in association with the anterior portion of the palato-quadrate process; in other amphibia, in lacertilians, in chelonians, in birds, and in mammals, these bones are developed in association with the basal plate of the nasal capsule. Here also we are led by the weight of other evidence to agree that the bones are homologous.

If then, it should be decided on the weight of other evidence to regard as homologous the parasphenoids of the amphibians and the pterygoids of the reptiles, we do not in this respect create a new precedent.

It would appear to be not improbable that the association of the reptilian pterygoid with the parabasal process is a secondary condition. This, quite apart from any decision as to the origin of the pterygoids from the parasphenoids, which, of course, involves such an assumption.

The parabasal process is present throughout the Amphibia, Reptilia and Aves, and amongst all these it is only in certain reptiles that any bony element is developmentally definitely associated with it.

In the face of these foregoing facts, we are justified in asserting that there is no evidence that the association of the pterygoids in certain reptiles with the parabasal process is a primitive condition departed from in the birds and mammals.

8. Conclusions.

Having now carefully reviewed the facts relative to the questions which have been herein discussed, it appears that the long-accepted view as to the homology of amphibian and reptilian pterygoid bones rested on an assumed association of the latter with the palato-quadrate portion of the subocular arch. This assumption is now shown to be erroneous. The recent attempt to support the old idea by quotation of series of labyrinthodont palates (quite unsupported as it is by other evidence, and depending only on the personal equation in deciding at which end of the series the comparison shall commence) is very unconvincing. Since the "Argument in Brief" summarises the present contribution, the conclusion may now be stated quite baldly.

(1) The reptilian pterygoid process or pars-palatina
    of the palato- or pterygo-quadrate cartilage is not
    in any way homologous with the palato-pterygoid
    or palatine portion of the amphibian or teleostean
    palato-pterygo-quadrate arch.

(2) The reptilian pterygoid process is homologous
    with the "pedicle" of the amphibian palato-
    pterygo-quadrate arch, and the name *parabasal*
    process is now proposed for both structures.

(3) The metapterygoid process of the teleostean sub-
    ocular arch is homologous with the shaft of the
    suspensorium in the Amphibia.

(4) The metapterygoid bone of the teleosts, the
    pterygoid bone of the Amphibia, and the ecto-
    pterygoid bone of the reptiles and labyrinthodonts
    are homologous bones.

(5) The pterygoid bones of the reptiles, birds and
    mammals are homologous bones.

(6) The pterygoid bones of the Sauropsida and
    mammals and the parasphenoid bones of the
    Ichthyopsida are homologous bones.

(7) Broom's identification of the reptilian para-
    sphenoid, anterior remnant of the amphibian
    parasphenoid, as the mammalian vomer, is
    accepted as correct.

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Index to Abbreviations used on the Figures.

ant. tip clin. proc.—anterior tip of the clinoid process.

ar.—articular.

art. car. ex.—arteria carotis externa.

art. car. int.—arteria carotis interna.

art. cer.—arteria cerebralis.

art. pal.—arteria palatina.

b. sph.—basisphenoid.

can. abd.—canalis abducentis.

can. art. cer.—canalis arteriae cerebralis.

can. pa. ant.—canalis parabasa-

lis anterior.

can. pa. post.—canalis parabasa-
lis posterior.

caps. aud.—auditory capsule.

cer. hy.—cerato hyal.

col.—columella auris.

con. occ.—occipital condyle.

cr. ba. pt.—crista basiptergoidea.

cr. parot.—crista parotica.

d.—dentary.

ect. pg.—ecto-pterygoid.

e. ot.—epiotic.

epi. pt. proc.—epipterygoid pro-
cess.

f.—frontal.

fen. ba.—fenestra basicranialis.

fen. hy.—fenestra hypophyseos.

fen. suboc.—fenestra subocula-
ris.

for. proot.—foramen prooticum.

gang v.—ganglion v.

gang vii.—ganglion vii.

hy. m.—hyomandibular.

hy. p.—hypophysis cerebri.

i. h. m.—inter-hyomandibular.

i. op.—inter-operculum.

incis. proot.—incisura prootica.

ju.—jugal.

memb.—membrane.

mes. pg.—mesopterygoid.

mk.—Meckel's cartilage.

mt. pg.—metapterygoid bone.

mt. proc.—metapterygoid pro-
cess.

n.—nasal.

op. cond.—opercular condyle.

ophth. sup.—nervus ophthalmi-
cus superficialis (or its fora-
men of exit).

orb. pr.—orbitar process.

os.—orbito-sphenoid.

op.—operculum.

ot. lab.—otic labyrinth.

ot. proc.—otic process.

p.—palatine.

p. op.—pre-operculum.

p. or.—pre-orbital.

p. pt.—pterygo-palatine.

pa. sph.—parasphenoid.

pal. pt. proc.—palato-pterygoid
process.

pal. qu.—palato-quadrate.

pars. lat. eth.—pars lateralis
ethmoidei.

pg.—pterygoid bone.

pila. proot.—pila prootica.

pr. ot.—prootic bone.

proc. al. par.—processus alisphe-
noidalis parietalis.

proc. b'pt.—processus basiptery-
goideus.

proc. epipt.—processus epiptery-
goideus.

proc. pa.—processus parabasa-
lis.

ps.—parasphenoid.

pt.—pterygoid bone.

pt. f.—post-frontal.

q.j.—quadratojugal.

qu.—quadrate.

r. pal. vii. and r.p. vii.—ramus
palatinus nervi facialis.

root vii.—root nervi facialis.

rost. sph.—rostrum basisphenoi-
dei.

so.—supraoccipital.

s. op.—sub operculum.

s. or.—suborbitals.

sq.—squamosal.

sym.—symplectic.

taen. syn.—taenia synoticum.

trab.—trabeculae.

vena jug.—vena jugularis.

vein.—an undetermined vein.

vo.—vomer.

ii.—Nerve ii.

v.—Nerve v.

vi.—Nerve vi.

vii.—Nerve vii.

v. brs.—branches of Nerve v.

THE PARABASAL CANAL AND NERVE FORAMINA AND CANALS IN THE BIRD SKULL.

By H. LEIGHTON KESTEVEN, D.Sc., M.D., Ch.M.

(Read before the Royal Society of N.S. Wales, July 1, 1925.)

Much of what is herein described and illustrated has already been recorded. Both Coues (1903) and Gadow and Selenka (1891) have described in general terms the situation of the various nerve foramina in the fowl, and the anterior and posterior openings of the parabasal canal. There is, however, a want of detail not only in the text but also in the illustrations, that renders the whole unsatisfying to the investigator requiring exact information as to the relation of these apertures to the bones of the skull for comparative craniological study. The course of the parabasal canal and the communication of this and a canal from the aqueductus fallopii in the substance of the basis cranii, has not heretofore been described, neither has the aqueductus fallopii itself.

Among the brief comparative notes relative to other birds, attention may be drawn to the statement that the olfactory nerves in the emu pass through a true cribriform plate. Coues (l.c.)quotes Owen as his authority for the statement—"The exit (of the olfactory nerve) is through a sieve-like or cribriform plate only in Apteryx and Dinornis."

Attention is also drawn to the correction of previous descriptions of the situation of the stapes and membrana tympani secundaria.

Part I.

Fowl and turkey skulls were dissected; no differences were observed.

The periotic, occipital, and basicranial bones are much thickened and cancellous. Where this cancellous bone is traversed by soft structures, those structures are ensheathed in tubes of condensed bone.

On the floor of the cranium, just within the foramen magnum, and perforating the basioccipital, there are on each side two small foramina (Fig. 1, nv. xii), a branch of the hypoglossal nerve passes through the more posterior of these. Their external apertures will be found on either side of the condyle.
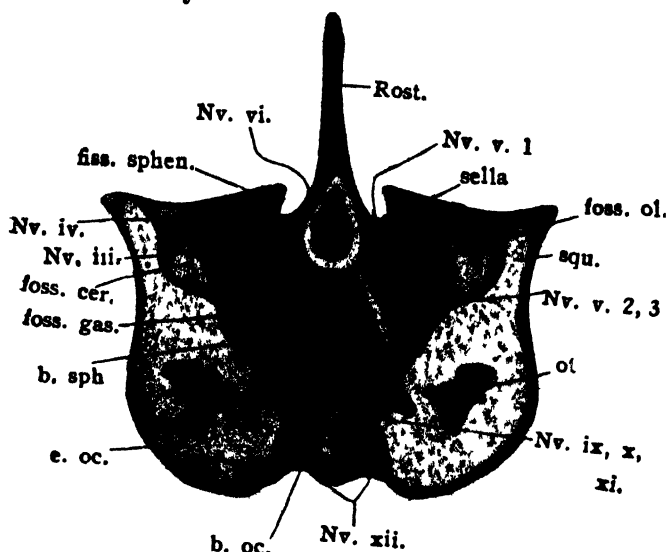
Fig. 1.—Cranial floor of the Fowl.

There is reason to believe that a smaller branch of the same nerve passes through the other foramen, and that the two canals are confluent, and have but a single external orifice, but this cannot be asserted with confidence.

A little further forward and further to the sides, in the petrosal bone, there is a deep fossa (Fig. 2, nv. ix, x, xi). This fossa lodges the glosso-pharyngeal and vagus ganglia.

There are two canals leading to the external surface from
the depth of this fossa. That which is the vago-accessory
foramen reaches the surface lateral to the hypoglossal
foramen. The other "glosso-pharyngeal" foramen will be
found on the median edge of the fossa parabasalis (*vide
infra*).
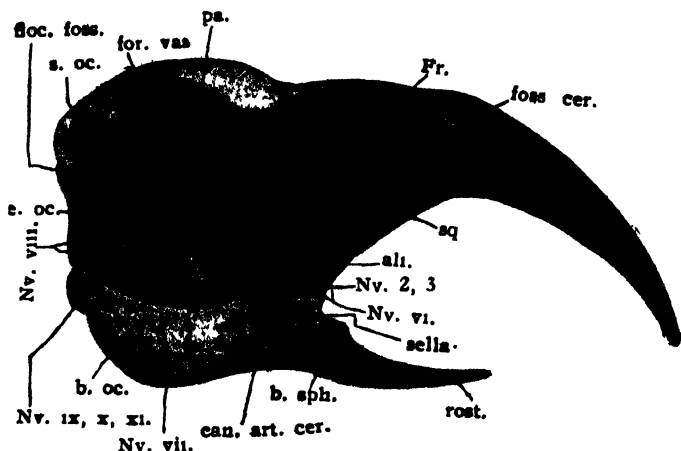
Fig. 2.—Cranial side wall of the Fowl.

The internal auditory meatus, at a little higher level
and in front of the ganglion fossa, is perforated for the
facial as well as the two branches of the auditory nerve.
The two foramina for the eighth nerve (Fig. 2, nv. viii.)
are placed above that for the facial (nv. vii.). The
auditory nerves have but a short course to their destina-
tion. The facial nerve has an interesting journey to the
surface; it will be followed later.

Immediately above the internal auditory meatus, the
deep floccular fossa may be seen (Fig. 2, floc. foss.). It
contains only a meningeal tag (Aracnoid).

Just in front of the internal auditory meatus, the side
wall of the cranium falls away to make room for the
olfactory lobes and cerebral hemispheres. The olfactory

fossa is clearly defined from that for the cerebrum by a
low ridge along its upper limit, and a further enlargement
of the cavity above it (Fig. 1, foss. ol., foss. cer.).

A shallow depression on the floor of the olfactory fossa
lodges the gasserian ganglion (Fig. 1, foss. gas.). The
gasserian fossa is perforated on its outer side by a double
foramen (Fig. 1, nv. v. 2, 3), the foramen prooticum,
or foramen ovale of mammalian craniology. It transmits
the second and third branches of the trigeminal nerve.
The double external aperture will be found in front of the
tympanic fossa (Fig. 3, nv. v. 2, 3). A single foramen
is also present entering a short canal which leads forward
from the front margin of the gasserian fossa. This trans-
mits the first branch of the trigeminal nerve. The anterior
opening, though within the cranial cavity, just to one side
of the sella, is the foramen rotundum of mammalian skulls
(Fig. 1, nv. v. 1).

The internal opening of the abducent canal is situated
on either side of the midline behind the sella. The canal
runs directly to the external opening below and in front
of the foramen rotundum, on the edge of the sella (Fig.
1, nv. vi.). In Figure 1 a bristle has been passed through
both the last two canals.

The sella is remarkably deep, extending back in the
substance of the basisphenoid almost as far as the internal
aperture of the abducent canal. At its depth two short
canals lead back and outward to the parabasal canals, to
be described later (Fig. 2, can. art. cer.).

The tympanic fossa presents several features of interest.
The well-defined bounding walls are interrupted by two
incisurae. The anterior or quadrate incisure (Fig. 3, incis.
qu.) is almost made good by the otic process of the quad-
rate when that is in position. The little glenoid cavity
(Fig. 3, glen.) for the head of the otic process is placed

in the overhanging broken wall. The process rests upon the broken lower edge as it crosses it to reach the body of the quadrate. There is a small passage left between the otic process and the cranium at the lower margin of the quadrate incisure.

The incisura posterior interrupts the posterior wall at a slightly lower level than the quadrate incisure.

Within the fossa several apertures are evident. Of these, that which is situated immediately behind the quadrate glenoid, is the fenestra rotunda (Fig. 3, fen. ro.). Below and behind this is a smaller foramen, in some skulls very obvious, in others smaller. A ligament, attached distally to the membrana tympani and extra columella, burrows into the bone through this foramen (for. lig.).

At a lower level still and a little further back (it is depicted a little too far forward in the drawing) is the fenestra ovalis (fen. ov.). Below this again the fossa extends deeply inward and forward. By a ridge on the hanging wall this recess is divided into upper and lower portions. The upper compartment ends blindly; the lower is the bony eustachian passage. The external aperture of the eustachian canal is found beneath the root of the rostrum basisphenoidei (Fig. 3, ext. ap. eust.).

Throughout this paper the openings named fenestrae rotunda and ovalis, are of a truth fenestrae ad fossulas fenestrarum rotundae et ovalis, the stapes and membrana tympani secundaria being deep within the two fossae. This statement, distinctly at variance with previous descriptions, has been verified by several dissections.

Immediately in front of and below the fenestra rotunda, there is a small foramen (Nv. vii., 1). This is situated at the fore end of a ridge which passes back below the fenestra rotunda and above the fenestra ovalis, and therefore above the stapes and columella. The ridge in question is hollow and is in part the aqueductus fallopii.

On the posterior aspect of the skull, immediately to the inner side of the posterior incisure of the tympanic fossa, there is a small deep fossa which has already been referred to under the name of fossa parabasalis. Besides the external aperture of the glosso-pharyngeal canal, already described, on its median boundary, there are two other openings in the fossa. The lower of these is the posterior opening of the parabasal canal; the other is the external aperture of the aqueductus fallopii.

The anterior aperture of the parabasal canal will be found above the external aperture of the eustachian canal and a little further back from the midline. It lies directly below the side wall of the sella about the centre of the antero-posterior length of the open portion (Fig. 3, par. can.).
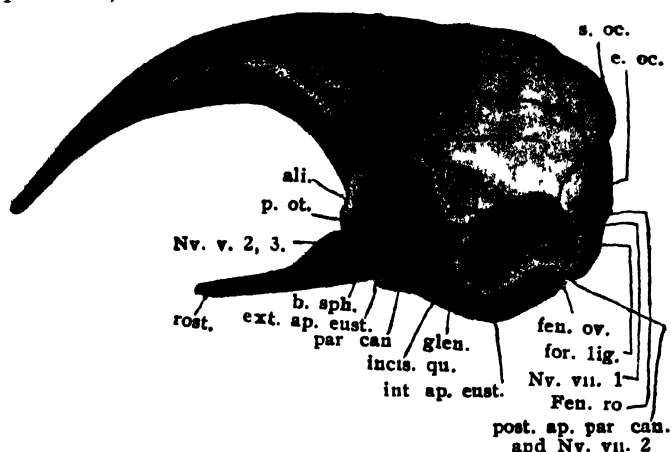
Fig. 3.—Outer view of cranium of Fowl from the side.

Having now fixed the various internal and external apertures of the parabasal canal and aqueductus fallopii and related canals, their course may be described.

From the internal "facial" foramen, the aqueductus fallopii with its contained facial nerve, passes first down

out and forward for a short distance, and then turns up-
wards and out (laterally) to join the canal within the
hollow ridge between the two fenestrae.   There is an
increase in the calibre of the canal at the junction, and
the main part of the nerve, increased in size, turns back
and issues from the posterior aperture of the aqueduct in
the parabasal fossa. A smaller branch turns forward and,
issuing from the small aperture on the fore end of the
ridge, passes inside the otic process of the quadrate in the
lower limit of the quadrate incisure and joins the second
and third branches of the trigeminal nerve as they issue
from the foramen prooticum.   Apparently there is a com-
munication between the hyomandibular division of the
seventh and the glosso-pharyngeal nerve in the parabasal
fossa.   The hyomandibular trunk comes forward through
the posterior incisure and runs down round the hinder
wall of the tympanic fossa, external to the membrana
tympanica.   It may be that a branch from the hyomandi-
bular division enters the parabasal canal with the internal
carotid artery.   The two structures are in sufficiently close
juxtaposition to permit the palatine branch to reach the
canal in this manner.

Just before the aqueductus fallopii bends up towards the
internal wall of the tympanic fossa, a delicate bony tube,
passing down medially and slightly forward, connects with
the parabasal canal.   This delicate tube carries nerve
fibres, probably the palatine branch of the nerve.

It is believed that the geniculate ganglion is situated at
the junction of the deep and superficial portions of the
aqueductus fallopii, where the nerve was observed to in-
crease in size and branch back and forward.

The point of this division is above and slightly in advance
of the fenestra ovalis.   The anterior branch of the facial
nerve doubtless carries the chorda tympani.   This nerve,

therefore, never actually crosses over the columella and stapes, because where it leaves the hyomandibular branch it lies above and in front thereof. The deeper portion of the aqueductus fallopii is situated in front of the fenestra rotunda. The chorda tympani apparently crosses under the otic process of the quadrate and over the parabasal process, dorsal to the body.

The parabasal canals travel a nearly direct course from point to point. A little behind the depths of the sella, each gives off a canal for the cerebral artery which passes forward, upward, and medially. The two openings into the sella are side by side at its extremity.

At the point of emergence from the parabasal canal the palatine branch of the internal carotid artery has the palatine branch of the seventh nerve on its outer side   It was possible to trace this nerve back as far as the delicate bony canal previously described with certainty. One was surprised also to find that there were nerve fibres alongside the artery behind this point.

The first branch of the fifth nerve rises dorsa¹ to the optic nerve passing between the attachments of the eye muscles and continues forward through the orbit close against the septum.

Of the combined fifth and seventh nerves which diverge from the foramen prooticum two turn down over the parabasal (anterior) process of the quadrate and pterygoid bone to the lower jaw. One runs forward along the floor of the orbit towards the lateral border thereof, and the last detected turns up and, crossing in front of the root of the post orbital process, continues round the bony margin of the orbit.

On the anterior wall of the olfactory fossa there are two faint grooves, one above the other. The lower is the impress of the oculomotor nerve and the upper that of the

pathetic nerve. These two nerves pass forward through the strong membrane which fills the large deficiency in the anterior wall of the cranium between the squamosal and frontal bones of either side and the basisphenoid below. Other nerves which reach the orbit at the edge of this extensive "sphenoptic fissure" are the abducent, first branch of the fifth nerve, and the optic, at the lower border, and the olfactory, close under the roof.

The olfactory nerves are not enclosed in bone in front of the membrana spheno-obturatoria, but lie free beneath the frontal and the dorsal horizontal expansion of the mesethmoid.

The term membrana spheno-obturatoria is used here, as in a previous contribution (Kesteven, 1919), to apply to the membrane which, in many incompletely developed skulls throughout the animal kingdom, and in a majority of fish, reptile and bird adult skulls, closes the deficiency in the cranial walls in the sphenoidal region. Gaupp's restricted use of the term, does not necessitate the search for another, when this is so completely descriptive.

Part II.

Throughout part II. only structures differing from those in the fowl will be described.

No. 1. THE EMU (*Dromæus novæ-hollandiæ*). The anterior wall calls for immediate comment; it is complete, and there is not only no spheno-obturator membrane, but also there is no sphenoptic fissure. The large optic foramina are separated by a bar of bone from the oculomotor foramen at their lower and outer border, and from the pathetic foramen at the upper and inner border. The external aperture for the abducent nerve is below and lateral to the oculomotor foramen, and has the foramen rotundum immediately above it. A deep recess in front under the roof leads to a true cribriform plate through which the olfactory nerve reaches the nasal capsule directly.

Noteworthy differences are observable in the tympanic fossa. The otic process of the quadrate extends back into the fossa for some distance. The eustachian tube has three bony walls only, the front wall is membranous. That section of the aqueductus fallopii which in the fowl passes directly back above the fenestra ovalis, in the Emu passes down behind the columella, inclining forward so that it lies below the level of the fenestra on the inner wall of the fossa. It is, moreover, an open channel in the dried skull, its superficial wall being membranous. It does not open into the fossa parabasalis, but in front thereof. The fossa parabasalis contains in its depth but a single foramen, that of the glosso-pharyngeal nerve.

The parabasal canal commences at the inferior termination of the open aqueductus fallopii. The palatine branch of the facial nerve leaves the hyomandibular trunk in this situation.

The anterior aperture of the parabasal canal is immediately in front of the eustachian canal behind the root of the basipterygoid process, and from this point the canalis arteriae cerebralis passes up and forward to the sella.

Reviewing the differences noted, those in the sphenoidal region are probably the most important.

It may be noted in passing, however, that quite recent text books of comparative anatomy designate the facet on the rostrum basisphenoidei, where the fore end of the pterygoid bone articulates, basi-pterygoid process, whereas a true basi-pterygoid process is present only in certain Ratites and Tinamous amongst recent birds. Compare in this connection figures 4 and 5. It may be further noted with interest, that in the emu at least, and probably in all birds having a true basi-pterygoid process, as in the reptiles, those structures which occupy the parabasal canal pass forward above the process, although in the emu, and

probably in those other birds, the canal terminates behind
the process, so that the nerve and artery are deflected
laterally and up, to cross above it.
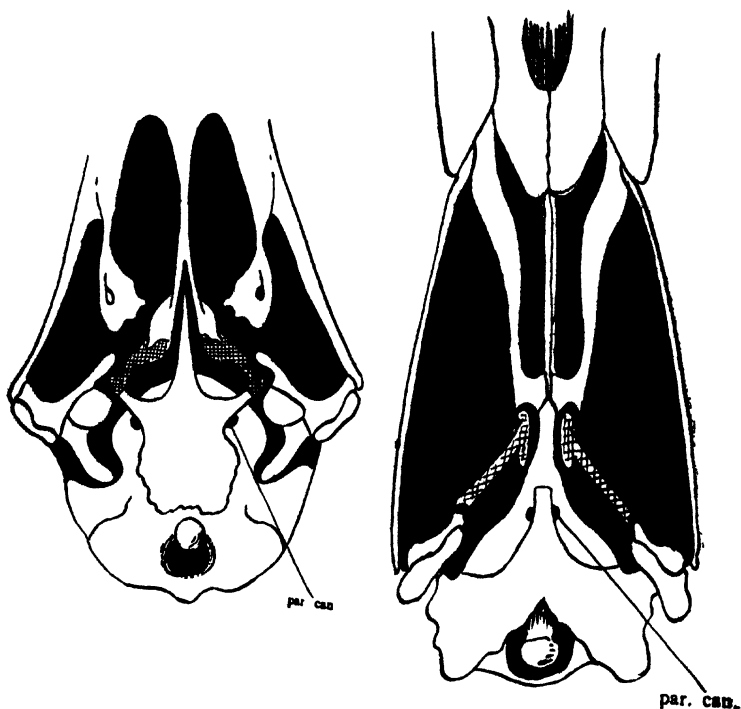
Fig 4.—Base of Dromæus skull to show basi pterygoid process.
Fig. 5.—Base of Anås skull for comparison with Dromæus.

No. 2.—THE DUCK AND SWAN: In these forms, as in the
Emu the posterior ·portion of the aqueduct of fallopius
turns down behind the columella in place of continuing
horizontally as in the fowl.

The parabasal fossa is more extensive than in the fowl
and has just within its median edge the vago-accessory
foramen. The glosso-pharyngeal foramen is situated well
within the fossa. There is no incisura posterior in the wall

of the tympanic fossa, the posterior wall is produced down to form a well-developed paroccipital process.

The front wall of the cranium differs from that of the Emu in two respects. There is a small deficiency high up on each side, in the fresh state completed by the reduced spheno-obturator membrane.

There is no cribriform plate, and the anterior end of the recess is some distance short of the posterior wall of the nasal capsule. Between the two the nerves lie under the frontal and mesethmoid as in the fowl.

No. 3.—THE CROW (*Corone australis*), the Magpie (*Gymnorhina tibicen*), the Laughing Jackass or Kookaburra (*Dacelo gigas*), the Australian Pheasant (*Centropus phasianus*), and the Butcher-bird (*Craticus destructor*).

Though presenting slight differences, these forms are sufficiently alike to be described together. In the sphenoidal region, these forms resemble the duck. The oculomotor, abducent, and foramina rotundum are so close together that viewed from in front it appears as though the nerves come through a common sphenoidal fissure. The sphenoidal deficiency is variable. In the butcher-bird, it is confined to the immediate neighbourhood of the olfactory foramen. In the magpie there is no deficiency.

In and around the tympanic fossa the resemblance to the arrangement in the duck is almost complete. No paroccipital process is developed. The Peewee (*Grallina picata*) differs from these in that the interorbital septum is deficient above, so that the two spheno-obturator membranes are continuous one with the other across the mid-line. The Spur-winged Plover (*Lobivanellus lobatus*) differs from the last form in that, as in the fowl, oculomotor and abducent nerves reach the orbit across the inner edge of a sphenoptic fissure.

No. 4.—PODARGUS: Sphenoidal region complete. Optic, abducent and oculomotor foramina distinct. The foramen ovale opens externally within, *i.e.*, on the tympanic aspect of the anterior incisure in the wall of the tympanic fossa. For the rest the resemblance is to the Emu, in so far as the situation of the canals is concerned. The inferior wall of the tympanic fossa is better developed and a paroccipital process of low prominence is developed.

No. 5.—AN EAGLE, which unfortunately is unidentified, and the Ibis, are the only bird skulls in the collection in which pathetic and optic foramina are confluent. For the rest, the sphenoidal region is as in the duck. The eustachian canal is open anteriorly throughout its length. The posterior segment of the aqueductus fallopii is perpendicular and is open in its upper half. The parabasal canal is deficient of bony wall on the tympanic aspect above the inner end of the eustachian canal. The otic process of the quadrate is continued well back into the tympanic fossa and divides the fossa into upper and lower compartments. The upper compartment has no medial wall, its place being taken by the very large fenestra rotunda. The lower compartment contains the remaining openings of interest usually present below the fenestra rotundum. This compartment has an intact front wall. In the upper front angle of this compartment an epitympanic recess is entered by a large opening; behind this the fenestra ovalis is obvious. The tympanic aperture of the aqueductus fallopii is between these two large openings, and the ridge between them is grooved by the hyomandibular branch as it turns back over the columella to enter the open portion of the aqueductus. There is a faint groove over the top of the front wall, and in the epitympanic recess there is a communication with the canal transmitting the second and third branches of the fifth nerve. Whether the anterior

branch of the seventh turns forward over the wall and under the otic process or through the tympanic recess to reach the branches of the fifth is uncertain.   The former seems the more probable; it would be in conformity with the conditions observed in other forms.

A fine foramen situated in the inner edge of the parabasal fossa leads into the internal auditory meatus on the left side, whilst on the right side such a connection cannot be demonstrated, though the external aperture is in the same place.

No. 6.—THE IBIS (*Carphibis spinicollis*) resembles the eagle in the confluence of optic and pathetic foramina, the peewee in the continuity of the two spheno-obturator membranes.   A paroccipital process is well developed.   The second and third branches of the fifth nerve leave through separate foramina.

No. 7.—Two PARRAKEET skulls (one *Platycercus* sp., the other unidentified) exhibit the same features and resemble the crow in all that is relevant, so nearly as to call for no further comment.

No. 8.—THE TOUCAN (*Rhamphastos* sp.) closely resembles the emu in all features cognate to the present investigation.   There is, of course, no cribriform plate.   The eustachian canal is complete.

An examination of the skulls of the foregoing sixteen species, reveals a fairly close adherence to the type set by the fowl skull.   Among variations noted are the following: the sphenoidal region may or may not be deficient in bone, and the deficiency, if present, made good by a spheno-obturator membrane.   Optic, oculomotor and pathetic nerves may penetrate the obturator membrane or issue through their own proper foramina.   Optic and pathetic foramina are at times confluent.   In the majority of the

cases the segment of the aqueductus fallopii behind the fenestra ovalis passes perpendicularly to the base of the skull, and the parabasal fossa lies further under the base than in the fowl. This portion of the aqueductus fallopii is at times open to the tympanic fossa for more or less of its length. The eustachian canal may be devoid of front wall. The hinder wall of the tympanic fossa may be developed into a para-mastoid or paroccipital process. A true basi-pterygoid process is present in the emu alone among the types studied (compare figures 4 and 5), and the palatine branch of the internal carotid artery and palatine branch of the seventh nerve on issuing from the front opening of the parabasal canal turn laterally and dorsally to cross above, dorsal to the process, as they do in the lizards.

The whole course of the palatine branch of the facial nerve alongside of the internal carotid artery in the para-basal canal is as in the lizards. The junction of the two canals, one through the substance of the prootic, the other through the basis cranii, the former carrying the palatine branch of the facial nerve, the latter the artery, and the subsequent course of the canals and structures forward of the point of junction described above in the fowl, resembles most remarkably the conditions I have elsewhere described in *Delma,* one of the Pygopod lizards (Kesteven, 1925).

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Explanation of Abbreviations.

ali.—alisphenoid.

b. oc.—basioccipital.

b. sph.—basisphenoid.

can. art. cer.—canal of the cerebral artery.

e. oc.—ex occipital.

ext. ap. eust.—external aperture of the eustachian canal.

fen. ov.—fenestra ovalis.

fen. ro.—fenestra rotunda.

fiss. sphen.—sphenoptic fissure.

for. lig.—foramen for columella ligament.

for. vas.—foramen for diploic vessel.

floc. foss.—floccular fossa.

foss. cer.—fossa cerebralis.

foss. gas.—gasserian fossa.

foss. ol.—fossa lobi olfactorii.

fr.—frontal.

glen.—glenoid cavity for head of quadrate.

in. ap. eust.—internal opening of eustachian canal.

incis. qu.—anterior incisure in the tympanic fossa wall.

ot.—otocranial cavity.

pa.—parietal.

par. can.—anterior aperture of the parabasal canal.

post. ap. par. can.—posterior aperture of the parabasal canal.

p. ot.—prootic.

rost.—rostrum basi-sphenoidei

sella.—sella turcica.

s. oc.—supraoccipital.

squ.—squamosal.

Nv. iii.—oculomotor foramen.

Nv. iv.—pathetic foramen.

Nv. v. 1.—foramen rotundum.

Nv. v. 2. 3.—foramen prooticum.

Nv. vi.—abducent foramen.

Nv. vii. 1.—foramen of exit of anterior branch of facial nerve.

Nv. vii. 2.—external aperture of the aqueduct of fallopius.

Nv. vii.—internal aperture of aqueduct.

Nv. viii.—internal auditory meatus.

Nv. ix., x., xi.—fossa for ganglia of nerves ix., x, and xi.

Nv. xii.—hypoglossal foramen.

NOTE ON THE IDENTITY OF UNCINEOL WITH EUDESMOL.

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(Read before the Royal Society of New South Wales, July 1, 1925.)

During the period 1915-1917 the author was engaged upon an examination of Australian sources of Terpineol, and consequently was led to examine the essential oil of *Melaleuca uncinata* with a view to isolating the solid alcohol of melting point 72.5° C. isolated therefrom by Messrs. Baker and Smith. These authors stated in their paper (Journ. Roy. Soc. of N.S. Wales, XLI. (1907), pp. 196-210), that it had a molecular formula of $C_{10}H_{18}O$, was dextro-rotary $[a]_D^{20°} + 36.99°$ in absolute alcohol, and bore a close resemblance in certain respects to Terpineol. The present author found that it was with considerable difficulty that this stearoptene could be separated in a condition of purity from the large quantity of accompanying sesquiterpenes, but that the more prolonged and rigorous the purification the greater its resemblance to Eudesmol—the principal sesquiterpene alcohol of the Eucalyptus oils—especially as the melting point was raised to 79-80° after purification, extending over a number of months. Quite recently a specimen was prepared of melting point 81-82° (fused material), which is the highest melting point yet recorded for this alcohol.

This investigation has now been completed, with the result that the stearoptene of the essential oil of *Melaleuca uncinata* is definitely shown, under "experimental," to be identical with Eudesmol, and that Uncineol has no separate existence.

Experimental.

The following collections of leaves and terminal branch-lets were made at Wyalong, N.S.W., during the years 1915-1917, and these on steam distillation yielded crude oils possessing the following characters:—

Yield	Sp. Gr. $\frac{15°}{15°}$	Opt Rot	Refractive Index 20°	Cineol contents	Ester No. Hot sap.	Ester No. after acetylation
1·21%	0 9342	+9·50°	1·4762	40%	4·34	108·48
1·00%	0·9274	+4·45°	1·4689	59%	2·02	56·14
1·00%	0 934	+8 00°	1·4727	46%	2·84	119·53
1·00%	0·9288	+4 60°	1·4700	53%	24·20	76·57

These oils were mixed together and distilled at atmospheric pressure, when the portion distilling at about 275-286° was reserved for working up the stearoptene. The fraction solidified to a butter like mass on keeping, and it was pressed on a porous plate to remove adhering sesquiterpenes. On repeated crystallisation from ethyl alcohol and water it was finally obtained as a white, feathery solid, which melted at 80°. It possessed $[a]_D^{20°} + 33.81°$ in chloroform, and gave a molecular weight result of 227 by the boiling point method (1.0698 gram in 31 c.c. acetone elevated the boiling point 0.34°) ($C_{15}H_{26}O = 222$). On keeping a quantity of about two grams, which completely occupied a 2-oz. bottle for a period of about twelve months, it changed to a viscous, resinous mass, which formed a layer of about 3 mm. at the bottom of the vessel. (See Baker and Smith, "Eucalypts," 2nd edition (1920), page 377, for particulars regarding this characteristic behaviour of Eudesmol.)

In March, 1924, a further consignment of leaves and terminal branchlets was procured from Wyalong, N.S.W., through the courtesy of Mr. G. I. Hudson, Sydney, in order to secure confirmation of the foregoing results. During the distillation the first, second and third hour

distillates were separately obtained in order to facilitate the isolation of the stearoptene. On account of their interest the chemical and physical characters of the three fractions are tabulated herewith:—

March, 1924: 144 lbs. leaves and terminal branchlets yielded 1.34% oil.

	1st hour	2nd hour.	3rd hr.
Yield of Oil.	0.76%.	0.34%.	0.24%.
Specific Gravity, $\frac{15}{15}°$	0.9223	0.9209	0.9475
Optical Rotation	+3.5°	+13.5°	+21.45°
Refractive Index, 20° ..	1.4631	1.4804	1.4976
Ester No.	1.0	2.61	5.86
Ester No. after acetylation	27.53	79.93	127.51

The third fraction was accordingly taken and worked up as described above. After repeated crystallisation, the alcohol was obtained as a white bulky mass of crystals, interlacing with each other in needles. It sublimed readily in acicular crystals, and was readily soluble in the usual organic solvents. The melting point of the white feathery crystals was 80.5° to 81°, whilst the white solid obtained by melting the crystals on the water bath melted sharply at 82°. On distillation at 10 mm. the crystals boiled at 155-156°, and had $[a]_D^{20°}$ + 33.45° in chloroform solution. 0.7330 gram in 23 c.c. acetone elevated the boiling point of the solvent 0.32°. Molecular Weight = 221. $C_{15}H_{26}O$ = 222.

The following results were obtained on combustion:—

(1) 0.1130 gram gave 0.3353 gram CO_2 and 0.1188 gram H_2O. C = 80.93%. H = 11.68%.

(2) 0.1192 gram gave 0.3518 gram CO_2 and 0.1250 gram H_2O. C = 80.49%. H = 11.65%.

(3) 0.1110 gram gave 0.3277 gram CO_2 and 0.1174 gram H_2O. C = 80.51%. H = 11.75%.

(4) 0.1000 gram gave 0.2960 gram CO_2 and 0.1054 gram H_2O. C = 80.73%. H = 11.71%.

$C_{15}H_{26}O$ contains. C = 81.08%. H = 11.71%.

Eudesmene hydrochloride.—The alcohol when treated with dry hydrochloric acid gas in glacial acetic acid solution at −20° yielded a white crystalline hydrochloride of the corresponding sesquiterpene, which when purified from ethyl alcohol melted at 75-76°.

0.0150 gram gave 0.0158 gram AgCl = 26% Cl.

$C_{15}H_{24}Cl_2$ contains 25.82% Cl.

Further proof of the stearoptene being a sesquiterpene alcohol was obtained by treating it with twice its volume of 100% HCOOH, when water was readily removed and a sesquiterpene resulted.

The latter was a colourless liquid, which possessed the following characters:—

> Boiling Point, 10 mm. .. .. .. 130-132°
> Specific Gravity, $\dagger \frac{1}{4}^\circ$ 0.9202
> Optical Rotation .. .. +30.2
> Refractive Index, 20° 1.5100

The specimen available was too small for rigorous purification, and attempts to induce the hydrochloride prepared therefrom to crystallise were unsuccessful. The striking colour reactions with bromine vapour in acetic acid and sulphuric acid in acetic anhydride (Journ. Roy. Soc. of N.S. Wales, LIV. (1920), pp. 205-6), were readily obtained.

I desire to express my thanks to Mr. F. R. Morrison, A.A.C.I., A.S.T.C., Assistant Economic Chemist, for much assistance in the investigation, and to Mr. G. I. Hudson for kindly furnishing a supply of material free of cost.

MULTIPLE BIRTHS,
THEIR CHARACTERISTICS AND LAWS
MATHEMATICALLY CONSIDERED.

By Sir GEORGE KNIBBS, C.M.G., M.I.I. de Stat.,

Hon. M.A.S.A., H.M.S.S. Hung., etc.

Synopsis.—1, General. 2, Masculinity of births. 3, Masculinity of population and of live-births. 4, Analysis of multiple births: twins. 5, Analysis of cases of triplets. 6, Multiple births of 4 or more. 7, Frequency of multiple births, various. 8, Effect of age-constitution of female population. 9, Effect of mother's age on frequency of twins and triplets. 10, Effect of duration of marriage on frequency of multiple births. 11, Secular increase in proportion of multiple births. 12, Twins in pre-nuptial conceptions. 13, Frequency of twins according to number of confinements. 14, Further questions and conclusions.

1. *General.*—Among demographic phenomena, those of multiple births in human reproduction occupy a unique place. When at a confinement more than one child is born, the births may arise from the insemination of as many ova as there are children born, or from a less number, the reason being that twins may be produced from a single ovum by division. When twins thus arise from a single ovum, they have a common chorion and are always either both males or both females, but never one of each sex; while births arising from separate ova may be indifferently of the same sex or of different sexes, and each has its own chorion. Children produced from separate ova we shall call diovular, triovular, etc., according as they arise from two ova or three ova, etc., but when two are produced from a single ovum we shall call them uniovular. Twins from one ovum have also been called univitellins; and, from two ova, bivitellins. We prefer the terms uniovular, diovular, etc.

It will be shown that, through the theory of probability, such an analysis can be made of human reproductivity, that, in cases of twins, triplets, etc., the relative frequency of both classes of reproduction can be deduced. In this connection it will be necessary to take into account the phenomenon of masculinity, viz., that generally there is a greater frequency of male than of female births, a frequency which is accentuated in the case of still-born children. We shall examine the laws of increase with age, with previous confinements, and with duration of marriage of the liability to multiple births.

2. *Masculinity of Births.*—The masculinity of births can be set out in several ways,[*] viz., the ratio of males to females, $\mu_1 = M/F$; the ratio of males to the sum of males and females, $\mu_2 = M/(M + F)$; and the ratio of their *difference* to their sum, $\mu_3 = (M - F)/(M + F)$. These are related to one another as follows:—

$$\mu_1 = \mu_1 = \mu_2/(1 - \mu_2) = (1 + \mu_3)/(1 - \mu_3)$$
$$\mu_2 = \mu_1/(1 + \mu_1) = \mu_2 = \tfrac{1}{2}(1 + \mu_3)$$
$$\mu_3 = (\mu_1 - 1)/(\mu_1 + 1) = 2\mu_2 - 1 = \mu_3$$

The mean of the annual masculinities of live-births and still-births, arranged in the order of the birth-rates per 1000 of the mean populations, are as follow:—

Period.	Country	Birth rate	μ_1 Live Births	μ_1 Still Births	Period	Country	Birth rate	μ_1 Live Births	μ_1 Still Births
1915-19	France	11.3	1053	1366	1915-21	Finland	23.7	1061	1306
1915-19	Austria	15.9	1056	1299	1915-20	Norway	24.3	1060	1267
1915-21	Switzerland	19.4	1051	1291	1915-22	Netherlands	26.2	1059	1248
1915-19	Hungary	19.8	1070	1235	1915-20	Iceland	26.7	1075	1112
1919-21	Belgium	20.2	1059	1311	1918-19	Bulgaria	27.5	1072	1390
1915-18	Sweden	20.9	1058	1259	1915-20	Spain	27.6	1098	1436
1921-	Greece	21.4	1163	1511	1915-22	U. Kingdom	28.7	1049	?
1915-22	Denmark	23.5	1055	1242	1915-20	Portugal	30.0	1057	1293

The masculinities for live-births and for still-births are both here given as so many males per 1000 females (μ_1).

[*] See G. H. Knibbs, Mathematical Theory of Population. Appendix A. Vol. 1, Australian Census of 1911, pp. 130-133.

The three means of the first eight quantities are respec-
tively 19.0, 1071 and 1314, and of the last seven are 26.6,
1069 and 1293. These means, and a review of the scatter
of the individual quantities, indicate that neither the
masculinity of live- or of still-births is affected by the
magnitude of the birth-rate itself. If the masculinities of
live-births are arranged in order of magnitude, the
averages of the first eight are respectively 1056.0, 1288.6,
and of the last seven are 1085.6 and 1322.4. The ratio
to one another is for the first 1.220 and for the second
1.218. Both are so near the general mean 1.219, that it
may be said that on the whole the masculinity of the still-
born is 1.219 times that of the live-births, and that it is
independent of the magnitude of the masculinity of live-
births. Either masculinity may be taken, therefore, to
express the probability of the production of fertile male
ova, viz., those which live or those which fail to attain
to other life than *in utero*. The range of the ratios from
year to year is, however, relatively considerable. Several
examples will suffice to indicate this :—

Ranges of Birth and Masculinity Rates.

	France.	Austria.	Belgium.	Finland.	Bulgaria.
Birth rate per 10,000 .	95-126	139-223	169-219	192-252	162-411
Masc. live births*	1046-1065	1046-1073	1054-1064	1057-1073	1062-1080
Masc. still births*	1313-1395	1269-1829	1287-1855	1315-1858	1211-1527

* Per 1,000 females.

3. *Masculinity of Population and of Live-Births.*—It
has been suggested by Düsing that masculinity at birth
is in some way related to the masculinity of population
(Das Geschlechtverhältnis im Königreich Preussen). The
masculinity of Australia's population has changed in a
way that might appear to afford some opportunity of
testing this idea, and the following table gives averages
for a considerable number of years—5 to 10—set out in
diminishing values of population masculinity. The mas-
culinities for individual years are somewhat irregular, so
that the trends must be examined for considerable averages.

Masculinities of Population and of live-births, each per 1,000 Females, Australia.

Period	1829-34	35-44	45-54	50-59	60-69	70-79	90-99	1900-13
Masc. Pop.	2961	2094	1404	1295	1233	1196	1147	1186
Masc. Births	1016	1028	1035	1032	1058	1045	1054	1058

These averages show unmistakably that as the masculinity of the population μ_p was decreasing, that of births μ_b was *increasing,* but whether the change should be regarded as merely a secular fluctuation, or as one in some way organically connected with the masculinity of the population, is by no means clear from the preceding results. If, however, the masculinities of the population of different countries be set out in decreasing order against the masculinity of births, either nuptial or ex-nuptial, it becomes clear that there *is* no general relation. The further examination of the question is beyond the province of this article. It will suffice to say that the result given can be closely expressed by a cubic equation with the reciprocal of the masculinity of the population as argument, viz. by $\mu_b = f(1/\mu_p)$, or by the following expression, viz. :—

$$\mu_b = M_a/F_b = 1.06 - 0.0325\,(\mu_p - 1) + 0.0333\,(\mu_p - 1)^{5/4}$$

in which M_a/F_b are average masculinities of the population.[*]

4. *Analysis of Multiple Births.—Twins*: It is desirable that full records of multiple births should be kept, showing the sex and indicating whether the cases are uniovular, diovular, etc. For the purpose of indicating the scheme of analysis we shall use as data those furnished from over 12,000,000 confinements in Germany.

During the period 1906 to 1911, there were in the German Empire, born from 12,013,134 confinements, 12,170,614 children, which included the following cases of twins, triplets, quadruplets and quintuplets, viz. :—

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[*] See **Mathematical Theory of Population, pp. 133-135.**

Twins.			Triplets.				Four.		Five.
2M.	Pairs.	2F.	3M	2M,1F	1M,2F	3F	M.	F.	(M. + F.)
49,425	58,882	46,637	343	390	395	361.	28	36	3
Cases Twins, 154,444			Cases Triplets, 1489.				Cases of 4, 16.		Cases of 5, 3.

Thus for a million confinements, there were 1,013,109 children; that is, about 77 children for every 76 confinements.

To analyse these it is to be noted that, in the case of uniovular twins, they are either both males or both females. In any attempt to ascertain the probability of the uniovular and diovular occurrences, we may assume that the masculinity of diovular cases of two males only to cases of two females only, applies also to uniovular cases.

Denoting the number of pairs of males by M, the number of pairs of females by F, and the number of pairs where there were one of each sex by P, and the ratio of the difference between the pairs of males and pairs of females to their sum by μ, we thus have for the masculinity :—

$$\mu = (M - F)/(M + F).$$

In the case of diovular twins the chances of the births in the orders MF and FM are obviously equal; the chance of MM to that of FF is $1 + \mu$ to $1 - \mu$; thus the ratios of the four diovular cases are as $1 + \mu : 1 : 1 : 1 - \mu$, each being very nearly one quarter of the total of the diovular cases. Owing, however, to masculinity, the cases MM are slightly in excess, and of FF slightly in defect, of the fourth part. In the case of the uniovular twins, since *ex hypothesi* the masculinity is not different, the cases of MM and of FF are also in the ratio $1 + \mu$ and $1 - \mu$, and there are, of course, *no* cases of MF or FM births; thus the ratios of the supposititious four uniovular cases are $1 + \mu : 0 : 0 : 1 - \mu$.

The cases of MM and FF in the total may, of course, be either uniovular or diovular, and their probability has now to be ascertained.

Obviously the number of diovular cases among the MM and FF births are together equal to the sum of the numbers of MF and FM births, that is to P, hence the number of uniovular births are $M + F - P$, and thus the ratio ξ of uniovular cases to the total cases of the twin births is

$$\xi = (M + F - P)/(M + F + P).$$

From the data, $M = 49425$, $F = 46637$ and $P = 58382$, we obtain $\xi = 37680/154444 = 0.243972$; $1 - \xi = 0.756028$ and $\mu = 0.0290239$. Hence the twins were made up as follows:—

	Total.	MM.	Pairs.	FF.
Cases of Uniovular Twins ..	37680	19387	None	18293
Cases of Diovular Twins ..	116764	30038	58382	28344
Total Cases of Twins	154444	49425	58382	46637

Total Number Children 308888   Ms., 157232; 151656 Fs.

It thus appears that approximately one fourth of all twins are produced from a single ovum.

The masculinity of all the males and females born as twins was 0.01805185, or 103,677 males per 100,000 females. From 1906 to 1913 the masculinity in Germany for *all* births was 0.0271, or say 105,570 males to 100,000 females. It is important to notice that the masculinity for all born as twins is slightly less than for *all* births.

From observations by Weinberg[*] and Ahlfeld,[†] the actually observed proportion of uniovular cases was 0.21 in a more limited number. Doubtless a larger number of cases would have approximated more closely to 0.24, as found above.

5. *Analysis of Cases of Triplets.*—Even the limited number of results for triplets will also admit of some analysis. It can, perhaps, be assumed that, among the

[*] Beiträge zur Physiol. u. Pathol. der Mehrlingsgeburten beim Menschen. Archiv. f. ges. Physiol. 1901, lxxxviii, p. 346. Also Neue Beiträge zur Lehre von den Zwillingen Zeit. f. Geb. u. Gyn. 1903, xlviii Hft. 1.

[†] Zeit. f. Geb. u. Gyn. 1902, xlvii, p. 280.

births in the órder MFM the chance of the two males
being uniovular is zero, and in the case of the order FMF
the chance of the two females being uniovular is also
zero. (Were this condition, however, not physiologically
impossible, it is obvious by exhaustive enumeration, that
the probabilities of the four cases, viz., 3M, 2M + F,
M + 2F, and 3F, would be respectively 0.2, 0.3, 0.3 and
0.2, provided the masculinity of the births were zero.)
As there were altogether 2204 male children to 2263 female
children born as triplets, and as the number of wholly
male triplets was 343 while that of the wholly female
triplets was 361, and further as there were 395 cases, where
there were two females, to 390, where there were two males,
the masculinity for triplets is clearly less than zero; that
is to say, the females preponderate.

Thus the several masculinities are:—

 Over all triplets ..   .. —0.013208
 Over male triplets and female triplets only —0.025568
 Over triplets of both sexes only; 1175M
     and 1180F ..   .. —0.002123

Since the sexes are identical in every uniovular case, this
last result suggests the existence of uniovular cases among
triplet births; that is, as triplets, they may be diovular
instead of triovular.

Let the masculinity be again denoted by μ; then if we
assume that μ is unequivocally deduced from the male
triplets and female triplets only, and is perhaps different
in other cases, the *triovular* cases only will then be in
the ratio

$$(1 + \mu) : 3 (1 + \kappa) : 3 (1 - \kappa) : (1 - \mu)$$

for 3M, 2M + F, M + 2F and 3F respectively. The
diovular cases among the triplets are equally likely, except
for the element of masculinity in the four cases; hence
they are in the ratio

$$(1 + \lambda) : (1 + \gamma) : (1 - \gamma) : (1 - \lambda).$$

In the above formulae μ, κ, λ and γ are regarded as all possibly different masculinities.

Let M, P, Q, F denote respectively the four classes of triplets above-mentioned, 3 males . . . 3 females: then, having regard to the possibilities of the two cases it may be assumed, as above shown, that there are as many cases of diovulation in P as in M, and in Q as in F, and, subject to the small masculinity modification, the same number in each case. Next let us first suppose that the masculinity is zero; and that the number of triovular cases is $8x$, and of diovular cases is $4y$; x and y being unknown. Then we would have:—

Triovular cases .. $8x = x + 3x + 3x + x$

Diovular cases .. $4y = y + y + y + y$

Thus the total is $8x + 4y = M = x + y$; $P = 3x + y$; $Q = 3x + y$; $F = x + y$;

and therefore $3(M + F) - (P + Q) = 4y$; consequently the ratio ψ of the diovular cases to the total would be given by

$$\psi = [3(M + F) - (P + Q)]/(M + P + Q + F).$$

Since, however, the masculinity terms cancel each other, both in $M + F$ and in $P + Q$, the formula is also correct when the masculinity is taken into account.

The values M, P, Q and F being 343, 390, 395 and 361, give $\psi = 0.891202$ for the total, and the triovular cases 0.108798; that is, there would be 1327 diovular births and only 162 triovular cases of triplets, or 10,000 triovular to 81,914 diovular cases. Thus the conception of triovular triplets would be only about 1 in 9.1914 cases of triplets.

We have seen that in the cases of twins the production from two ova is about 0.756 of the whole; in cases of triplets the production from three ova would appear to be only 0.109 of the total.

For the value of μ we have, as before,

$$\mu = (M - F)/(M + F).$$

With the values $M = 343$ and $F = 361$, this gives $\mu = 0.025568$.

When we take account of the masculinities we have for the symbolic values of M, P, Q and F, respectively

$$(x + y) + (\mu x + \lambda y); \quad (3x + y) + (3\kappa x + \gamma y);$$
$$(3x + y) - (3\kappa x + \gamma y); \quad (x + y) - (\mu x + \lambda y)$$
$$(P - Q)/(P + Q) = (3\kappa x + \gamma y)/(3x + 2y); \quad (-\kappa).$$
$$(M - F)/(M + F) = (\mu x + \lambda y)/(x + y); \quad (-\mu).$$

Thus if the ratio of κ to γ is known the first is solvable, since x and y can be deduced, and the value of λ is discoverable since μ is known.

We have found $8x = 162$ (the triovular cases) and $4y = 1327$ (the diovular cases); thus $x = 20.25$ and $y = 331.75$; and we have found also that $\mu = -0.025568$.

First, in regard to the masculinity: we see from the last formula that we must assume $\lambda = \mu$, then we get the two supposed values for μ identical. Secondly, from the formula preceding the last we see that if $\gamma = \kappa$, we have also the value of κ directly given. From the data it is $-5/785 = -0.0063694$. Using this value and $\mu = -0.025568$, we find that the triplets may be divided as follow :—

Types of Cases.	Total.	M.M.M.	M.M.F.	M.F.F.	F.F.F.
Triovular Cases	162	20	60	61	21
Diovular Cases	1327	323	330	334	340
Total Cases	1489	343	390	395	361

The femininity of the triplets is remarkable and *a priori* would not have been expected.

The infrequency of triovulation, viz., 162 cases in 12,013,134 confinements, or one case in 74,155 confinements, is also remarkable. The data quoted give for the different cases, the number of confinements in which 1 twin, 1 triplet, etc., will occur,

	Twin.	Triplet.	Quadruplet.	Quintuplet.
Data given	77.776	8067.2	750,758	4,004,378

6. Multiple Births of Four or More.—In the cases of the *quadruplets* the numbers $M = 28$ and $F = 36$ give for the masculinity over all —0.125, a very high value of femininity. Thus we have

	All confinements.	Twins.	Triplets.	Quad-ruplets.
Masculinity (about 0.0271)	+0.029024	—0.025568	—0.125

Cases of *quintuplets* were about 1 in 4 million confinements in the German Empire. They have been reported by Volkmann,[*] Düsseldorf; by A. Bernheim,[†] Philadelphia; by Horlacher,[‡] Wurttemberg; by Nyhoff,[||] Groningen. It may be mentioned that in 30 cases referred to by the last-named the majority were born after a period of four to five months' gestation.

Sextuplets were reported by Vassali[§] and Vortisch and Alburi.[**]

7. Frequency of Multiple Births, Various.—The frequency of multiple births differs greatly in various countries. Thus per 10,000 confinements they ranged in Italy from 80 for Basilicata to 148 for Venice, while for other countries they had the following values during various periods:—

Number of Twins per 10,000 Confinements.

Spain	87	Bavaria ..	123	Prussia ..	129
Roumania ..	88	Saxony ..	123	Hungary ..	131
France ..	109	Austria ..	126	Wurttemberg	132
Belgium ..	111	Switzerland	126	Norway ..	133
Italy	117	Germany ..	127	Sweden ..	146
Russia ..	121	Baden	128	Finland ..	147

Australia, with 98 per 10,000 (see hereunder), has a low value relatively.

For the 35 years 1881 to 1915, there were the following cases per million confinements in Australia. Population

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* Zentral, Bl. f. Gyn. 1879, p. 17. † Deutsche Med. Wochenschrift 1899, p. 374. ‡ Horlacher, Württ., Korr. Bl. 1840. || Zeitschr. f. Geb. u. Gyn. 1903, Bd. lii, p. 173. § Anatom. Anzeiger, Bd. x, No. 10. ** Münch. Med. Wochenschr. 1903, No. 38, pp. 1639–40, a photograph being given.

aggregate, 34,208,424, the females being 16,204,832. The cases of multiple births were in the following ratios:—

Confinements.	Twins.	Triplets.	Quadruplets.	5 or more.
1,000,000	9,802	82.9	1.50	0
665,919	6,527	53.2	1	0
For the German Empire.				
1,000,000	12,856	124	1.33	0.25

8. *Effect of Age-constitution of Female Population.*—The constitution of a population according to its sex and age, and the general age at which their reproductivity takes on its most active phase, affects the frequency of multiple births, as the following table shows in regard to the excess over one at a birth.

Excess over 1 child due to Multiple Births.
Australia 1907 to 1914.

Ages	Nuptial Cases Confine-ments	Excess over 1	Ex-nuptial Cases Confine-ments	Excess over 1	Ages	Nuptial* per 10,000 Smoothed	Ex-nuptial per 10,000 results
12	0	0	5	—	12	0	0
13	4	0	21	—	13	6	7
14	30	0	126	—	14	13	14
15	170	0	587	1	15	19	21
16	1138	2	1500	2	16	26	28
(16.39)	(2017)	—	(2017)	—	—	—	—
17	3962	12	2980	11	17	32	35
18	9761	35	4504	15	18	38	42
19	18071	94	5317	22	19	45	49
20-24	207335	1332	21541	154	20	51	56
25-29	265444	2442	9603	93	25	83	91
30-34	201495	2598	4754	68	30	115	126
35-38	111625	1740	2423	45	38	166	182
	Change in		ratio of excess				
39	20790	326	436	5	39	153	168
40-44	52490	653	1029	11	40	141	154
45-49	5244	36	130	1	45	76	84
50	34 .	0	5	0	50	13	14
51	12	0	1	0	51	0	0
52	6	1	0	0	—	—	—
53	4	0	1	0	—	—	—
54	3	0	0	0	—	—	—

* Per 10,000 confinements.

An analysis of these results shows that the ratio increases from age 12 to age 38 inclusive, both in nuptial and ex-

nuptial cases, and then falls off, the excess over 1 disappearing after age 51. Denoting the age last birthday by x, the results can be represented by the formulae:—

Nuptial Cases—

$\beta_n = 1 + 0.00064 \ (x - 12)$ to age 38 incl.;

$= 1.01664 - 0.00129 \ (x - 38)$, 39 to 51 incl.

Ex-nuptial Cases—

$\beta_e = 1 + 0.00070 \ (x - 12)$ to age 38 incl.;

$= 1.01820 - 0.00140 \ (x - 38)$, 39 to 51 incl.

The fewness of the results after age 45 in the nuptial cases, and after age 39 in the ex-nuptial ones, makes the end values of the table slightly uncertain.

9. *Effect of mothers' age on frequency of twins and triplets.*—The table showing the excess over 1 per confinement is very nearly a table showing the frequency of twins according to age, owing to the fact that the frequency of triplets is relatively so small. Australian experience from 1907 to 1914 gives the following results:—

Twins and Triplets Australia 1907-1914.

Ages.	Confinements.		Twins.		Total.		Ratio.
	Nuptial.	Ex-nuptial.	Nuptial	Ex-nuptial	Twins.	Triplets.	
15-19	33,102	14,838	144	50	194	1	.0052
20-24	207,835	21,541	1324	150	1474	14	.0095
25-29	265,444	9,603	2417	96	2513	19	.0076
30-34	201,495	4,754	2585	68	2653	26	.0098
35-39	132,415	2,859	2039	46	2085	34	.0163
40-44	52,490	1,029	641	11	652	11	.0169
45-49	5,244	130	36	1	37	0	0
50-54	59	7	1	0	1	0	0
Totals	897,618	54,913	9187	422	9609	105	.0109

Thus the frequency of nuptial twins for all ages was 0.01023 of the nuptial confinements, and of ex-nuptial 0.00768 of the ex-nuptial confinements, or of all twins, 0.01009. The frequency of triplets was 0.0109 of the twins.

The ratio of all twins to all confinements and of all triplets to confinements is as shown in the last two columns of the preceding table, which gives the twins per 100,000 confinements and triplets per 1,000,000 confinements. The last line gives the relative frequency of triplets to twins.

Ages	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54
Twins	405	644	914	1286	1542	1218	689	1515
Triplets ..	21	61	69	126	251	206	0	0
Ratio, 1 in ..	193	156	133	102	61	59	—	—

Thus, as we saw in the formula for the excess over 1 birth, the rise for twins continues to the age-group 35-39 and then diminishes. The *excess* over unity for nuptial and ex-nuptial twin-cases is sensibly given respectively by

$\epsilon_n = 0.000632\ (x - 12)$ to age 38 incl.;

and $0.01643 - 0.001264\ (x - 38)$, for 39 to 51 incl.

$\epsilon_e = 0.00670\ (x - 12)$ to age 38 incl.;

and $0.01772 - 0.001363\ (x - 38)$ for 39 to 51 incl.

10. *Effect of duration of marriage on frequency of multiple births.*—In order to make an analysis of this it is obvious that the age effect ought to be eliminated: this, however, is impracticable. Constructing a table, however, of confinements and the resulting twins (including triplets) and triplets we get:—

Cases of Twins and Triplets Australia 1908-1914.

Duration Marriage.	Confts.	Twins incl. trip.	Triplets.	Duration Marriage	Confts.	Twins incl trip	Triplets.
0-1	134,171	1129	9	9-10	32,170	417	3
1-2	61,213	460	8	10-15	116,777	1638	20
2-3	64,229	465	4	15-20	58,698	839	14
3-4	70,317	564	8	20-25	24,363	280	3
4-5	59,407	551	2	25-30	4,173	36	1
5-6	53,275	504	4	30-35	143	0	0
6-7	47,250	468	1	35-40	1	0	0
7-8	41,713	492	8				
8-9	37,115	466	7	Total	805015	8308	77

This makes the ratio of cases of twins to confinements 0.010320, and of triplets to twins 0.00927. It gives peculiar

results, however, as to the ratio of twins to confinements, as see the following per 10,000 confinements and triplet-ratios per 10,000 twins respectively.

Age group	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	14-15	19-20	26-27
Twins ..	84	75	72	80	93	95	99	118	125	130	160 (Max.)	137	70
Triplets ..	80	78	66	68	71	74	72	78	77	88	128	164	—

The triplet-ratios are ascertained from the means of 11 age-groups except in the first five cases, which are the means of the group of 1, 3, 5, 7 and 9.

11. *Secular increase in the proportion of multiple births.*—There is a marked secular increase in the frequency of multiple-births in Australia, as is shown by the following table:—

Secular increase in numbers and ratios of Multiple-births; Australia 1881-1915.

Period.	1881-9	1890-9	1900-9	1910-5	Total 1881-1915
Confinements, Cases of ..	680,562	899,109	977,268	772,655	3,329,594
2 or more children	6,026	8,827	10,097	7,967	32,917
3 or more children	38	73	98	72	281
4 or more children	1	2	1	0	4
* Ratio for twins	8,854	9,817	10,332	10,311	9886
* Ratio for triplets .. .	55.8	81.2	100.3	93.2	84.4
* Ratio for 4 or more;* per 1,000,000 confinements.					1.2

The increase of the ratio of cases of twins per million confinements was thus 101.4 per annum for the 9-year period; then 51.5 for the 10-year period; afterwards it fell off 2.5 per annum. The matter is worthy of further study when the statistics are available.

12. *Twins in prenuptial conceptions.*—A very remarkable phenomenon in the frequency of twins is the fact that it is high for prenuptial conceptions, as the following table shews:—

Ratio of Twins born various periods after Marriage; Australia 1908-15.

Months after Marriage ..	0-3	3-6	6-9	9-12	12-24	24-36*	36-48*	48-60*	48-84*
Twins in 10,000 Confts.	101	80	101	77	76	73	89	91	92
Ratios range between	67-127	72-111	88-129	65-86	69-95	(* First births only).			

The results given above for 24 to 84 months are for first-births only, and are during the period 1908-14.

The ratio of twins for 7-11, and 11-26 years, was only 77 and 78, over all (0-26) it was 82, while for 1-26 it was only 79.

With triplets the ratio for years 0-1 was 71; for 1-4, 78; for 5-26, 87; and for years 1-26 it was 88; but these results depend on but very small numbers and no inference can be drawn from them.

13. *Frequency of twins according to number of confinements.*—As age increases with number of confinements, it is impracticable to distinguish between effects due solely to age (?) from those due solely to the number of previous confinements. The frequencies according to previous issue indicate approximately the following results:—

Previous confinements	0	1	2	3	4	5	6	7	8	9	10
No. per 10,000 confinements	82	96	107	117	124	130	134	136	138	139	140
Calculated by form .	85	96	106	115	122	130	134	138	141	142	143

The results are very closely expressed by the formula
$$N = 143 - 0.58 \ (10 - C)^2$$
in which N = the number of twins per 10,000 confinements and C is the number of previous confinements.

14. *Further questions and conclusions.*—When the data are extensive enough to admit of it, it may be possible to eliminate from such results as have been given, all confusion due to the effects of secular changes in such questions; for example, as the influence (a) of the duration of marriage, and (b) of the number of previous confinements upon the frequency of multiple-births. It may also be possible to make small corrections in the analysis of cases of multiple-births for changes in masculinity. Moreover, we shall see that it is not impossible that the admixtures of age of husbands and of wives have some effect.

Their influence upon the frequency of confinement itself is very marked, as has been shown by Körösi of Budapest, and by ourselves*. It has also been shown by ourselves that there is an effect due to the ages of husbands and wives, which for Australia, 1907 to 1915, was as follows:—

Twin-Diisogency. Frequency of Twins (and Triplets) according to ages of husbands and mothers, Australia 1907-15.

Age groups.	Under 19	19	20	Ages of Mothers. 21-4	25-9	30-4	35-9	40-5	45-54	All ages	Trip-lets ÷ Twins 25-39	Trip-lets ÷ Twins All ages
Under 19	57	211	—	—	59	—	—	—	—	121	—	—
19-20	46	46	69	2	59	—	—	—	—	44	—	—
21-4	41	58	68	67	89	129	218	—	—	69	183	128
25-9	28	40	54	64	91	126	124	174	—	81	109	82
30-4	25	39	54	63	90	129	157	150	—	102	53	83
35-9	—	51	48	58	95	124	154	117	128	120	55	98
40-4	—	—	62	64	91	122	156	124	51	129	83	92
45-9	—	—	138	65	105	127	152	118	67	128	176	145
50-4	—	—	—	39	87	154	148	93	83	116	304	198
55-9	—	—	—	—	64	95	120	158	74	117	285	289
60-4	—	—	—	—	92	175	102	148	86	129	—	—
65-9	—	—	—	—	—	308	112	—	—	131	—	—
Ages 25-39	25	41	53	63	91	127	153	125	128			
All ages	37	53	61	64	91	127	153	119	73	102	All triplets	
Triplets ÷ Twins 25-39	—	—	54	69	79	164	329	—			÷	
,, All ages	—	56	75	82	81	150 155	—		99	All twins 99		

In all cases the ratios are per 10,000; that is, 10,000 confinements for twins, 10,000 twins for triplets. A review of the ratios on the horizontal lines shows at once that there are systematic differences. In general the frequency of twins increases up to age 39 for the mother. A similar examination of the vertical lines shows that the differences are irregular. Thus, although the age of the husband has a very definite influence on the maternity-ratio itself, it has apparently none at all upon the ratio of twins to confinements.

At present there are not sufficient cases to ascertain with any precision the triplet-diisogency for Australia, but the

* See Korosi, Phil. Trans Vol. 186, pt. II., pp. 781-875 and G. H. Knibbs' Math. Theory of Population, pp. 356-369.

ratios of triplets per 10,000 twins is approximately as follows:—

Husbands.	Ratio to 10,000 twins.		Ratio to 1,000,000 mothers.*	
	Wives under 30.	Wives 30 & over	Wives under 30.	Wives 30 & over
Under 30	68	269	50	360
30 and over	84	109	70	144

* Of same age-group

It may be assumed that, since apparently the age of the husband has no influence on the frequency of twins, it has none in the case of triplets. Taking the final horizontal line on the preceding table as indicating the effect on the ratio of twins (for all husbands) according to the age of mothers, we have the following results:—

Ages of mothers ..	20	21–4	25–9	30–4	35–9	40–4
Per 10,000 twins ..	56	75	82	81	150	155
Calculated by formula	49	57	73	97	129	171

This result is very irregular, and no simple and probable expression will fit it. Probably the number of triplets T per 10,000 twins is sufficiently well given by

$$T = 49 + 0.16 (x - 20)^2$$

to indicate the general law of their occurrence.

The frequency of twins according to age and order of confinement needs much more exhaustive study, as has already been shown by us.* Maternity is powerfully influenced by social traditions and contraceptive practices, but in the occurrence of multiple births, physiological laws doubtless alone operate. For this reason, both students of demography and others are interested in the measurement of the various uniformities which are revealed by a study of the reproductive phenomena of the human species.

One of the most remarkable conclusions to which these studies lead, is a recognition of the intensification of the femininity of a population by its multiple-births. Thus for the German Empire the masculinity of all births was 1.056 (1906-13). Among twins it was reduced to 1.037,

among triplets to 0.974, and among quadruplets to 0.778, which reduction is sensibly as the cube of the number of the excess of births, over 1, and is given by

$$\mu = 1.056 - 0.0103N^3,$$

where N is the number over 1 of the multiple-births 0, 1, 2, 3, etc. This formula gives per 1000, 1056, 1046, 974 and 778 instead of 1056, 1037, 974 and 778.

Another result of importance is the fact that, with twins, 756 in 1000 are produced from two ova, and 244 by the division of one ovum, while in the case of triplets only 109 in 1000 are produced from three ova, while 891 are produced by the division of one ovum and the fertilisation of a second ovum. We can see better relatively what is occurring by setting out the cases thus:—

Confinements, 1,000,000—

    Twin cases, 12,856.   Triplet cases, 124.
= 2 ova, 9719; 1 ovum, 3137.   3 ova, 14; 2 ova, 110
which indicates how rare triovulation is. For very rough estimates of relative frequencies we may say that twins occur once in 100 confinements, triplets once in 10,000, quadruplets once in 1,000,000 and quintuplets twice in 10,000,000.

Australia, as time goes on, can afford valuable material for the study of all the intricacies in the laws of the growth of a population, but at present we are not recording the facts with the thoroughness that might be desired.

THE ESSENTIAL OILS FROM THE LEAVES OF *MURRAYA KOENIGII* (SPRENG.), *MURRAYA EXOTICA* (LINN.) AND *MURRAYA EXOTICA* VAR. *OVATIFOLIOLATA* (ENGLER).

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Although it has long been known that the leaves of the various species of *Murraya* contain essential oils yet, so far as the authors are aware, no detailed investigation of the oils present in the leaves of the three species, *M. Koenigii*, Spreng., *M. exotica*, Linn., and *M. exotica* var. *ovatifoliolata* (Engler) has been made (for previous literature see Gildermeister and Hofmann Vol. I., p. 541, II. 648.). Since *M. exotica* is found both in Australia and in India, we decided to collaborate in the investigation of these oils.

M. Koenigii, Spreng. occurs in the Outer Himalayas from the Ravi eastwards ascending to 5000 feet, in Assam, Chittagong, Upper and Lower Burma, Chutia Nagpur, Bengal and in the evergreen and deciduous forests of the Peninsula where it is somewhat uncommon.

M. exotica, Linn., is found in the Sub-Himalayan tract from the Ravi eastwards ascending to 4500 feet, in Assam, Upper and Lower Burma, Chittagong, Behar, the Satpura range, Chutia Nagpur, the hills of the Peninsula and in the Andamans.

The botany of the Australian variety, *M. exotica* var. *ovatifoliolata* (Engler) is described in "Comprehensive Catalogue of Queensland Plants" (Bailey) page 82, the description of *M. exotica* in Bentham's "Flora Australiensis," Vol. i., p. 369, also probably refers to this plant. It occurs chiefly in Queensland and is undoubtedly the indigenous form of *M. exotica*. It is a shrub or small tree with bright green leaves and in habit is rather more straggly than the type, but possesses distinctive botanical characters, which readily differentiate it from *M. exotica*, Linn.

The examination of the three oils has shown them to resemble one another in that all of them consist chiefly of sesquiterpenes. This fact, taken in conjunction with the very low yield of oil, renders them unsuitable for economic exploitation. The low yield was partly accounted for by the fact that unless the leaves were subjected to steam distillation immediately after collection decomposition, with loss of material, took place. This loss could be avoided to some extent in the case of the Indian oils since the leaves were collected in the vicinity of the laboratory, but with the Australian oil (from *M. exotica* var. *ovatifoliolata*) the leaves had to be air-dried in the shade to allow of their transportation from Queensland to Sydney. In the moist state decomposition with loss of oil was rapid.*

The oil from *M. Koenigii* has been found to be the most interesting, since it was found to contain, in addition to *a*-pinene and *l*-caryophyllene, the bicyclic terpene sabinene, which was apparently present in the racemic form as it yielded on oxidation *dl*-sabinenic acid, an acid not previously described. The acid which, when anhydrous melted

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* During the examination of this oil, small quantities of resinous substances, probably glucosides, were separated, but repeated attempts at purification were unsuccessful.

at 84-85°, was identified by direct comparison with a speci-
men of the racemic acid prepared from equal parts of the
d- and *l-* forms.

The oils from the two species of *M. exotica* yielded only
sesquiterpenes and sesquiterpene alcohols. The chief con-
stituent of the Indian oil was found to be *l*-cadinene
identified by its hydrochloride, whilst bisabolene was simi-
larly identified as one of the sesquiterpenes present in the
Australian oil. The other, the main sesquiterpene and
sesquiterpene alcohol, could not be identified, since they
did not yield any crystalline derivatives with the usual
reagents.

Experimental.

(1) *The Essential Oil from* Murraya Koenigii, *Spreng.*

The oil used in the experiments described below was
obtained by the distillation in steam (30 lbs. pressure) of
the freshly gathered leaves of *M. Koenigii* collected at
Dehra Dun. The yield of oil (0.04 per cent.) was found
to be somewhat variable and to diminish rapidly if the
leaves were kept for more than a day after collection. The
oil, which was pale yellow in colour, had a somewhat
unpleasant smell and gave the following constants:—
Sp. Gr.$\frac{30°}{30°}$ 0.8711, R.I. 30°C = 1.478, $\frac{Optical}{Rotation}$ —18.2°, acid value 1.1,
saponification value 11.06, saponification value after acety-
lation 31.83.

A quantity of the oil was distilled under diminished
pressure (100 mm.), when the following fractions
resulted:—

Table I.

No.	B.Pt. (100 mm.)	D$\frac{15°}{15°}$	N$_D$$^{0°}$	$[a]_D^{20°}$	Yield %
I.	95-115°	0.8476	1.468	—5.67°	9.8
II.	115-130°	0.8515	1.465	—4.83°	20.4
III.	130-170°	0.8674	1.4776	—6.34°	11.9
IV.	170-190°	0.895	1.4942	—15.53°	47.5
V.	190-240°	0.8973	1.489	–	9.0

Fractions I. and II. were systematically refractionated at the ordinary pressure, when ultimately the following fractions were obtained:—

Table II.

No.	B.Pt. (698 mm.)	D$\frac{15°}{15°}$	N$_D^{20°}$	$[a]_D^{20°}$	Yield % (calc. on the original oil)
1.	155-158°	0.8413	1.462	—6.06°	5.7
2.	158-160°	0.8413	1.463	—4.8°	6.1
3.	160-165°	0.8441	1.464	—4.02°	10.7
4.	165-170°	—	—	—	2.0
5.	170-185°	—	—	—	2.9
6	130-170°/100 mm.	0.8674	1.4776	—6.34°	14.3
7.*	170-190°/100 mm.				
8.*	190-240°/100 mm.				

Fractions 1 and 2.—These two fractions consisted essentially of a-pinene since on treatment with amyl nitrite under the usual conditions they yielded copious precipitates of pinene nitrosochloride which melted and decomposed at 119°. The a-pinene was probably mainly *dl-a*-pinene, since it yielded on oxidation *dl*-pinonic acid, no active pinonic acid being obtained.

Fraction 3.—Examination of this fraction showed it to be a mixture. When treated with amyl nitrite it yielded a small quantity of pinene nitrosochloride, showing the presence of a-pinene. When the hydrocarbon was oxidised with potassium permanganate in alkaline solution under the conditions described by Wallach (Annalen, 1908, *359*, 265), a sparingly soluble sodium salt was obtained which crystallised from hot water in fine needles. The acid, which was obtained from the sodium salt on acidification, was purified by crystallisation from water, from which solvent it separated in fine glistening needles. When air-

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* From Table I.

dried it melted at about 58°, but on keeping in a vacuum desiccator over sulphuric acid the crystals gradually decrepitated owing to the loss of water of crystallisation, and the melting point of the anhydrous acid was found to be 84-85°. In alcoholic solution it was found to be optically inactive.

This acid was identified as *dl*-sabinenic acid, which does not appear to have been described previously. It was found to be identical in every respect with a specimen of this acid prepared by the admixture of equal parts of *d*- and *l*-sabinenic acids.

The racemic acid was found to retain the water of crystallisation very tenaciously, since a specimen dried for twelve hours in a vacuum desiccator over sulphuric acid gave the following figures on analysis:—0.0602 gram gave 0.137 CO_2 and 0.0462 gram H_2O: C = 62.0, H = 8.5. $C_{10}H_{16}O_3$, $\frac{1}{2}H_2O$ requires C = 62.2, H = 8.8 per cent.

A specimen of the acid dried for some days over phosphorus pentoxide was found to be anhydrous:—0.1085 gram gave 0.2496 gram CO_2 and 0.1035 gram H_2O: C = 65.5, H = 8.5. $C_{10}H_{16}O_4$ requires C = 65.2, H = 8.7 per cent.

dl-Sabinenic acid resembled in its general properties the active forms of the acid, but was much more soluble in water, whilst the sodium salt also showed a greater solubility.

Fraction 4.—This fraction was too small in quantity for examination.

Fraction 5.—Careful tests showed the absence in this fraction of terpinene and phellandrene. When dissolved in acetic acid and treated with bromine in ice-cold solution a small crystalline precipitate was obtained. This melted at about 120° and was possibly dipentene tetrabromide, but the quantity was insufficient for recrystallisation.

Fraction 6.—This fraction, after treatment with alcoholic potassium hydroxide solution to hydrolyse any esters present, was refractionated under diminished pressure (100 mm.), when it was readily separated into two main fractions 6(*a*) distilling below 130° and 6(*b*) distilling at 170-190°. Fraction 6(*a*) (yield 3 per cent. calculated on the original oil) was found to be nearly pure *dl*-sabinene, since on distillation at the ordinary pressure it was found to boil at 160-165°. Fraction 6(*b*) (yield 10 per cent.) was found to consist of *l*-caryophyllene (see below).

Fractions 7 and 8.—Fraction 7, which formed the main bulk of the distillate, was combined with fraction 8 and heated for some hours with excess of an alcoholic solution of potassium hydroxide. After addition of water the neutral oil was separated, the alkaline solution being reserved for later investigation (see below). The oil was purified by distillation, when practically the whole boiled at 178-185°/100 mm. After two distillations over sodium it was found to boil at 178-180°/100 mm., and to have the following constants:—D$^{20°}_{4°}$0.8946, N$^{20°}_{D}$1.4992 [α]$^{20°}_{D}$—12.65° : 0.1217 gram gave 0.3925 gram CO_2 and 0.1299 gram H_2O; C = 87.9, H = 11.9.

$C_{15}H_{24}$ requires C = 88.2, H = 11.8 per cent.

An examination of this sesquiterpene has shown it to be *l*-caryophyllene. It yielded a nitrosochloride melting at 158-160°, a nitrosate which decomposed at 162°, whilst on treatment with sulphuric acid in acetic acid solution caryophyllenic alcohol melting at 94-96° was formed and gave a phenyl urethane melting at 136°.

In addition to *l*-caryophyllene a small amount of a high boiling oil, probably a sesquiterpene alcohol, was separated, but it was insufficient in quantity for purification.

Combined Acids.—The alcoholic potassium hydroxide solution (see above) was evaporated on the water bath until

free from alcohol, cooled and acidified, when a sparingly
soluble semi-solid acid separated. This was taken up with
ether, the ether dried and evaporated, when an oil re-
mained which partially crystallised. After trituration with
a little dilute methyl alcohol the solid was collected,
drained on porous porcelain and recrystallised from methyl
alcohol, when it was found to melt at 61-62°, and was iden-
tified as palmitic acid by the method of mixed melting
point. The methyl alcohol contained a small amount of a
liquid acid, which was not further examined.

(2) *The Essential Oil from* Murraya exotica, *Linn.*

The leaves of this shrub, grown at Dehra Dun, yielded
on distillation in steam a small quantity of oil, the yield
being about 0.01 per cent. It was very dark in colour and
possessed an unpleasant smell. It had the following con-
stants:—$D_4^{15°}$ 0.9023, $N_D^{15°}$ 1.496, saponification value 8.87,
saponification value after acetylation 72.53, solubility in
80% alcohol—insoluble in 10 volumes.

The oil (40 c.c.) was distilled under diminished pres-
sure (10 mm.), when the greater part (34 c.c.) distilled at
125-142°. Since, owing to the small quantity of material
available, it was not possible to separate the sesquiterpene
alcohol present in a pure state, the total distillate was
repeatedly fractionated over sodium, when ultimately a
pale yellow oil (15 c.c.) was obtained, which boiled at
129-131°/10 mm. It had the following constants:—
$D_4^{15°}$ 0.8946 $N_D^{15°}$ 1.4988, $[\alpha]_D$—78.2°.

On treatment with hydrogen chloride a crystalline hydro-
chloride melting at 118-119° was obtained, and this was
identified as cadinene hydrochloride. The yield was small,
and this, taken in conjunction with the physical constants,
indicated the presence of a second sesquiterpene, which was
not identified. During the distillation it was observed that

the oil was distinctly fluorescent, indicating the possible
presence of methyl anthranilate.

(3) *The Essential Oil from* Murraya exotica, *var.*
ovatifoliolata, *Engler.*

Three different samples of the leaves and terminal
branchlets of this shrub, grown at Eidsvold, Queensland,
were distilled in steam, the results obtained being shown
in the following table :—

Table III.

Date	Weight of leaves	Yield per cent.	D¼°	N⅝°°	[α]ᴅ	Saponification Value	Saponification value after acetylation
27/11/22	66 lbs.	0.15	0.9126	1.5008	—24.7°	19.37	68.55
31/1/24	68 lbs.	0.06	0.9117	1.5004	—10°	26.18	—
17/3/24	167 lbs.	0.12	0.9121	1.499	—14°	19.83	—

The oil from the last two distillations (53 c.c.) was
washed with dilute alkali to remove the free acids and,
after hydrolysis of the esters present with alcoholic potas-
sium hydroxide solution, was distilled under diminished
pressure (10 mm.), when it was separated into two main
fractions, (1) 110-129° (8 c.c.) and (2) 129-133° (40 c.c.).
Repeated distillation of the oil, the lower fractions being
distilled over sodium, resulted in the separation of three
main fractions, fractions I. and II. comprising about 80
per cent. of the total distillate.

Table IV

No	B.Pt. 10 mm.	D¼°	N⅝°°	[α]ᴅ
I.	124-128°	0.9004	1.497	—12.2°
II.	128-131°	0.908	1.4999	—10.2°
III.	145-152°	—	—	—

Fractions I. and II. were found to consist of sesquiter-
penes and yielded the usual colour reactions with bromine
and sulphuric acid. The former, on treatment with hydro-
chloric acid gas in dry ether, did not yield a solid deriva-
tive until it had remained in the ice-chest for over twelve

months, when a number of crystals were observed dissemi-
nated through the viscous mass.   These were separated,
and after re-crystallisation from ethyl alcohol melted at
79.5-80°C.   This crystalline derivative proved to be a tri-
hydrochloride, identical with bisabolene :—

0.0322 gram of sesquiterpene chloride gave 0.0430 gram
AgCl, equal to 33.03% Cl. $C_{15}H_{24}$ 3HCl yields 33.97% Cl.
The other sesquiterpene present, which appeared to be
concentrated in fraction II., could not be characterised,
since it did not yield any solid derivatives.

Fraction III. was shown to be a sesquiterpene alcohol and
gave on treatment with formic acid a hydrocarbon; neither
the latter nor the alcohol yielded crystalline derivatives
with the usual re-agents.

Free Acids.—The alkaline solution with which the ori-
ginal oil had been washed gave on acidification a crystalline
acid which melted at 62.5° and was identified as palmitic
acid.

Combined Acids.—The alcoholic potassium hydroxide
solution with which the oil had been hydrolysed was evapo-
rated to a small bulk, acidified with dilute sulphuric acid
and distilled in steam, when a mixture of acids was ob-
tained partially soluble in water.   The silver salts of the
soluble and insoluble acids respectively were prepared and
analysed :—

0.3094 gram gave 0.114 gram Ag.   Ag = 46.5%.
0.4072 gram gave 0.1756 gram Ag.   Ag = 43.1%.
$C_8H_{15}O_2$ Ag requires Ag = 43.0 per cent.

The principle acid present in combination would there-
fore appear to be caprylic acid.

In conclusion, the authors desire to express their thanks
to Dr. T. L. Bancroft, Eidsvold, Queensland, and Mr. R.
N. Parker, Forest Botanist, Dehra Dun, for the supply of

the material used in this investigation, and Mr. F. R. Morrison, Assistant Economic Chemist, and Mr. T. P. Ghose Assistant to the Forest Chemist, for help in the experimental work.

DESCRIPTIONS OF SIXTEEN NEW SPECIES
OF EUCALYPTUS.

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These descriptions are more or less uniform in presentation to the nine papers of "Notes on Eucalyptus" by Mr. Maiden, the last of which appeared in this Journal, Vol. liv., 1920. Two of the proposed new species in the present paper should be quoted as Maiden, the remaining fourteen as Maiden and Blakely.

Eastern Species.	*Western Species.*
1. *E. Bloxsomei* Maiden	7. *E. albida* Maiden and Blakely
2. *E. Dwyeri* Maiden and Blakely	8. *E. Burracoppinensis* „
3. x*E. Kalangadooensis* „	9. *E. cylindriflora* „
4. *E. microneura* „	10. *E. Desmondensis* „
5. x*E. Westoni* „	11. *E. Dongarraensis* „
6. *E. Whitei* „	12. *E. Kesselli* „
	13. *E. Kondininensis* „
xSuggested hybrids.	14. *E. Merrickae* „
	15. *E. ovularis* „
	16. *E. Staerii* Maiden

1. E. BLOXSOMEI Maiden, n. sp.

Bloodwood, cortice flavo, ligno pallido. Foliis juvenilibus petiolatis, ovatis, leniter peltatis, tenuibus, venis secundariis remotis, e costa media circiter 60-85° orientibus; foliis maturis flavo-viridibus, paulo nitentibus, petiolatis, lanceolatis, falcatis, venis secundariis parallelis, approximatiusculis, e costa media 40-45° orientibus; inflorescentia umbellis ad 9 in capitulo paniculas non confertas terminales corymbosas formantibus, ala-

bastris glaucis, calycis-tubo sub-cylindraceo, costato; operculo-conico, calycis tubi longitudinem dimidio æquante; fructibus urceolatis, magnis, 1.5-2 cm. longis, 1 cm. maximo diametro, margine depresso, pedicellis brevibus, pedunculis longis.

A bloodwood of medium size, with yellow, flaky bark, known as "Yellow Jacket" or "Yellow Bloodwood." Timber pale-coloured, and not reputed durable.

Juvenile leaves petiolate, ovate to ovate-lanceolate, slightly peltate, thin, the rachis rough with minute glandular papillae, the secondary veins roughly parallel and distant, making angles of about 60-85 degrees with the midrib. The intramarginal vein distant from the edge.

Intermediate leaves large and broadly lanceolate, acuminate, 10-17 cm. long, 5-7 cm. broad, paler than the adult leaves, slightly rough, the branches acutely quadrangular.

Mature leaves thickish, yellow-green, moderately shiny, or of an egg-shell lustre, petiolate lanceolate, falcate, 12-19 cm. long, 2-3 cm. broad, secondary veins moderately distinct, parallel and moderately close, making angles of about 40-55 degrees with the midrib; intramarginal vein rather close to the edge.

Inflorescence: Umbels up to 9 in the head, forming moderately loose, terminal corymbose panicles. Each umbel on a long peduncle, each flower on a short but distinct pedicel. The buds glaucous, the calyx-tube sub-cylindrical, ribbed and abruptly tapering into the pedicel, 10 mm. long, 5 mm. broad at the top. The operculum conical, half the length of the calyx-tube and wider in greatest diameter than the calyx-tube. Anthers of the Corymbosae.

Fruits urceolate, large, 1.5-2 cm. long and 1 cm. in greatest diameter, rim countersunk, the capsule well sunk, pedicels short, peduncles long. They exhibit a longitudinal vein-like appearance when dry, owing to the shrinkage which exposes the fibro-vascular bundles.

The type is from Hippong, Queensland; Herbert Schreiber Bloxsome, in whose honour the species is named. He has taken great trouble to furnish information and specimens.

Range.

Confined to Southern Queensland, so far as we know at present. Parish of Boondooma, 70 miles N.W. of Wondai (Forest Guard Higgins, August, 1918). In large quantities in the Chinchilla State Forest on the Condamine Water (the Main Range runs right through it). Locally known as "Yellow Jack" or "Yellow Jacket" (Forest Ranger G. Singleton, September and October, 1918, through C. T. White). "Bloodwood (Yellow-barked)." Received under this name from Dr. T. L. Bancroft from Hippong, June, 1919. This is Mr. H. S. Bloxsome's property, and I have been receiving specimens and notes from Mr. Bloxsome ever since, in spite of a very severe drought.

Found on hungry sandstone, and its precise area not yet defined. It occurs in the Chinchilla State Forest on the west (this to the north includes Hippong; Boondooma is to the east, and is on the Boyne River). A line connecting Chinchilla (on the Brisbane to Roma Railway) and Mundubbera (west of Gayndah, on the Maryborough to Mundubbera Railway) would run approximately through the centre of the known *E. Bloxsomei* country, where it is more or less mixed with another yellow-barked Bloodwood (*E. Watsoniana*), and therefore some care in the bush is necessary. Hippong, Wondai and Boondooma are on the Burnett Waters, that empty into the sea at Bundaberg.

Affinities.

This new species is interesting, in that it connects *E. peltata* and *E. Watsoniana,* species whose phytogenetic re-

lations were not very clearly defined. They exhibit simi-
larity to the present species in bark and timber, seedlings,
and in fruits. For some time I looked upon it as a variety
of *E. peltata,* but for the reasons which follow, I think the
interests of science will be better conserved by recording
it as a species.

1. With *E. peltata* F.v.M. It differs from *E. peltata*
in the much larger pedicellate fruits and in the scarcely
peltate juvenile leaves. In the majority of specimens of *E.
peltata,* the buds and fruits are sessile, or, when pedicel-
late, only shortly so, while they are constantly pedicellate
in *E. Bloxsomei.* The buds and fruits appear to vary more
than in *E. peltata;* some are nearly as small as in *E. pel-
tata,* while others are considerably larger, reminding one of
small fruits of *E. Watsoniana.*

The seedling of *E. Bloxsomei* differs from that of *E.
peltata* in having alternate leaves after the first pair. In
one seedling it is alternate immediately after the cotyle-
dons. There are as many as six pairs on one seedling of
E. peltata and only two on another. In *E. Bloxsomei,* the
peltate character is more retarded; it only appears in one
leaf at 6 inches, the two other leaves after are not peltate.
In *E. peltata,* the peltate character sometimes starts with
the second pair of leaves and continues for a long period,
at least until the seedling attains a height of 12 inches.

Almost from the earliest stage, or at least from 3 inches
in height, the leaves of *E. Bloxsomei* are larger and
broader than those of *E. peltata.* The intermediate leaves
are also produced much earlier in *E. Bloxsomei* than in
E. peltata. The setae of *E. Bloxsomei* are finer and shorter
than those of *E. peltata.*

To sum up, the seedling *E. Bloxsomei* appears to be
closer to *E. Watsoniana* than to *E. peltata.* The opposite
character of the leaves is the same in both species.

2. With *E. Watsoniana* F.v.M. The large fruits of *E. Bloxsomei*, with their comparatively longer and more slender pedicels, more strongly resemble those of *E. Watsoniana* than *E. peltata*. We have specimens of *E. Bloxsomei* from Wondai with small pedicellate fruits and buds. The latter are not glaucous, as the buds of *E. peltata*. I have already dealt with some resemblances to *E. Watsoniana*.

2. E. DWYERI Maiden and Blakely, n. sp.

Mallee ramosa, foliis obscuris, foliis maturis crassiusculis, lanceolatis, petiolatis, venis aliquantum conspicuis, venis secundariis e costa media circiter 45° orientibus, inflorescentia in umbellis ad 7 in capitulo, in pedunculis paulum planatis, pedicellis brevibus vel absentibus; alabastris nitentibus, operculis attenuato-conicis, calycis longitudine cum tubo æquantibus; antheris versatilibus, atque ex Macrantheris; fructibus paulum urceolatis vel campanulatis, hemisphericis vel sub-cylindraceis, brevioribus, margine latiore et fere horizontali, valvis exsertis.

Usually a small branching Mallee, but, like some of the Mallees, it may exceptionally attain the dimensions of a small tree. The foliage dull-coloured, drying olive-green.

Juvenile leaves narrow-lanceolate, but not seen in the earliest state. Intermediate leaves (not seen from type locality) broadly-lanceolate.

Mature leaves moderately thick, lanceolate, petiolate, the venation not very conspicuous, slightly spreading, but the secondary veins on the whole parallel, and make an angle of about 45 degrees with the midrib; the intramarginal vein distinctly removed from the edge.

Inflorescence in umbels up to seven in the head, on slightly flattened peduncles up to 1.5 cm. long, the pedicels short or absent. The buds shining and brown in colour, operculum attenuate-conical, of the same length as the calyx-tube, which is scarcely ribbed, and which tapers

gradually into the very short pedicel.   Anthers versatile, opening in parallel slits, gland at the back; belonging to the Macrantheræ.

Fruits slightly urceolate or campanulate, hemispherical or sub-cylindrical, rather small, up to about 9 mm. in greatest diameter, rim broadish and nearly horizontal, the valves whitish (through a thin discal membrane), and distinctly exsert.

Type from Gungal, near Merriwa, N.S.W., preferring ridges (J. L. Boorman, September, 1904).

In honour of the Right Reverend James Wilfred Dwyer, Roman Catholic Bishop of Wagga, N.S.W., who, when Parish Priest of Temora, collected this species on several occasions, and who has been an acute observer of native plants for many years.

Range.

So far it has been recorded only from New South Wales, and in moderately dry, but not very dry, areas.   In view of the fact that it is a Mallee, and That it is superficially similar to at least two other species, we confidently predict that its range will be considerably added to in the near future.

At present we know the species from three main areas— (1) Between the Murrumbidgee and the Lachlan Rivers, which may be briefly described as the Temora-Wyalong country; (2) the Merriwa-Denman area, where the type came from; and (3) the Pilliga Scrub.   Outliers from (1) are the Nymagee district, and from (3) the Warrumbungle Mountains.

Definite localities are:—

On quartzite ridge, Ardlethan (R. H. Cambage, No. 4192); small or medium sized trees of 12-40 feet high, growing on the ridges around the township and at the

mines (J. L. Boorman) ; small to medium-sized trees, having much the habit of a Red Gum, bark dark grey, ribbony
towards the base of the stem, Wyalong (J. L. Boorman) ;
Wyalong (W. S. Campbell, 1901) ; Red or Cabbage Gum,
Barmedman, on ridge (R. H. Cambage, 16th September,
1900).

Temora, Nos. 112, 499, 835 (Rev. J. W. Dwyer). "A
gum resembling *E. tereticornis,* smooth bark, deciduous,
dark grey or greenish, bluish on trunk, but creamy on
branchlets. About 20-30 feet high. Fruits remind one of
E. Stuartiana." Road Temora to Mirrool (Rev. J. W.
Dwyer, No. 196). "A straggling, low, branchy type, resembling Mallee, bark of a gum tree, smooth, varying in
colour from grey to white. About 12 feet high." Temora
State Forest, 10 miles from Temora (Forest Guard C. O.
Love, Nos. 6 and 7, 1918).

A Mallee, Blow Clear State Forest, 8 miles north of
Bogan Gate (K. Walker, Nos. 5 and 6, 1918) ; growing in
Mallee form, 8 or 10 stems from one root, and about 20 feet
high, Wirlong, Nymagee (R. H. Cambage, No. 1011) ;
referred to as *E. tereticornis* var. *dealbata* (*E. dealbata*) by
Mr. Cambage in *Proc. Linn. Soc., N.S.W.,* xxvi., 204, 1901,
and by Mr. Maiden as resembling the Gungal specimens,
ib., xxix., 773, 1904.

Sent in as "A." "A small tree of branching habit, no
stem, specimens were obtained from the young shoots, was
not able to form any idea as to size. Top of hill in one
locality only." Gungal, near Merriwa (J. L. Boorman,
September, 1904). Another specimen, also labelled "A2,"
and labelled "Mallee." Piece of timber with this.

Sent in as "B." "Mallee-like trees or shrubs, tops of
the hills; on the flats not plentiful. Timber of this." Gungal, near Merriwa (J. L. Boorman, September, 1904). "In

the vicinity *Grevillea longistyla* and *Philotheca australis* var. *Reichenbachiana* grow. . . . The Eucalypts are
very interesting, and, so far as my knowledge goes, they
are new, with affinity to *E. tereticornis* var. *brevifolia.*
. . . There is a large quantity of *E. trachyphloia* growing on the sides of the hills all over the district'' (J. L.
Boorman, September, 1904).

Growing like Mallee on sandstone, top of Mount near
Shale Mine, Baerami, west of Denman (R. H. Cambage,
No. 2687).

About 14 miles west of Dunedoo, near Merrygoen railway
station. A Mallee about 10 feet high, with thin straight
stems, 2-3 inches in diameter. Bark smooth, blotched.
Leaves somewhat glaucous, young branches reddish. Buds
somewhat stellate, yellowish, very numerous (Andrew
Murphy, January, 1924). Mr. Murphy also states that it
grows ''all over'' the Warrumbungles and is the common
Mallee of that part.

Now we come to the Pilliga district. ''A Mallee-like plant
of 8-12 feet, stems 3-6 inches in diameter, tips of twigs
claret-coloured. On stony ridges at a high altitude.
Forked Mountain, Coonabarabran. On the road Gunnedah
to Coonabarabran, about 4-5 miles from the latter township. Found (by me) in one spot only of the eastern fork,
in the vicinity of the Mission Station'' (J. L. Boorman,
September, 1908). (This is Burra, Bee Dee, the Aboriginal
Station, 6 or 7 miles from Coonabarabran.)

1. ''Mallee-like habit, but probably *E. dealbata.*'' Labelled No. 1. 2. ''Clean-stemmed Mallee with galls. Labelled No. 2. Fruit larger than No. 1.'' (Both Pilliga
Scrub, near middle) (Dr. J. B. Cleland, 7th October, 1918).

''Mallee.'' Growing in isolated patches amongst Curracabah scrub on sandstone country with clay subsoil. Parish

Milner, County White (Forest Guard E. H. F. Swain, No.
10, 14th July, 1912). "Mallee," poor heathy lands, south-
east Pilliga (E. H. F. Swain, No. 6, August, 1913).

"Resembles a young *E. tereticornis.* Collected from
saplings about 4 inches butt diameter (mature gums grow-
ing among them. It was taken for granted they were of
the same species as the saplings, but from superficial obser-
vation there appeared to be no buds or fruits on the mature
trees. The mature trees grow 4-5 feet girth, and about
40-50 feet high, branching, and as a rule crooked.) Im-
provement Lease 1777, Parish Brigalow, Co. Pottinger, in
company with *E. trachyphloia,* etc. (Forest Guard M. H.
Simon, No. 110, August, 1913). That the species attains
a height of 40-50 feet seems doubtful, or at all events to be
proved (J.H.M.). Gum, 40 feet high and 12 inches in
diameter. Timber and bark available. Forest Reserve
35919, Parish Brigalow, Co. Pottinger, Gunnedah district,
June, 1915 (Forest Guard M. H. Simon, No. 8).

Affinities.

Although on the probationary list for nearly twenty
years, its specific rank was confirmed when seeds from a
large number of specimens attributed to *E. dealbata* were
sown, and a very fine series of seedling plants compared.
Two series of seedlings resulted, the true *E. dealbata* with
broad leaves, and *E. Dwyeri* with narrow ones. We have
here an illustration of the desirability of raising seedlings
as a check on determinations otherwise obtained. It may
be mentioned that the leaves of the seedlings of *E. pumila*
are, like those of *E. dealbata,* broad. Further details will
be given when the seedlings of a large number of species
are described, when it will be found that in the Bilobae, *E.
Dwyeri* comes in Section No. 21, "Narrow-lanceolate,"
while *E. dealbata* and *E. pumila* are in No. 23, "Semi-
terete to quadrangular; petiolate (elliptical to orbicular)."

1. With *E. dealbata* A. Cunn. Compare Plates 134 and 135, Part xxxii., "Crit. Rev."* An outstanding difference between the two species lies in the broad juvenile foliage of *E. dealbata;* the pedicels of the same species are more defined, the calyx-tubes and fruits more hemispherical, never sub-cylindrical, while the opercula are more conoid, and, when elongated, never as much so as in *E. Dwyeri.* *E. dealbata* is a small or moderately large tree, probably never a Mallee; its bark is rougher and the timber red.

2. With *E. pumila* Cambage. See Plate 206, Part L., "Crit. Rev." Both species are Mallees, but the juvenile leaves of *E. pumila* are broad, while those of *E. Dwyeri* narrowish. The peduncles and pedicels of the former are shorter and thicker, and the pedicels are more sharply defined from the hemispherical fruits, while the rims are more domed. The buds of *E. pumila* are more attenuate, both as regards opercula and calyx-tubes.

3. With *E. siderophloia* Benth. A suggestion, as regards fruits, is the above, but *E. siderophloia* is not closely allied to *E. dealbata.* Specimens from Arrarowine, Borah Creek, Pilliga Scrub, a small white gum with smooth bark, labelled *E. siderophloia* by Dr. H. I. Jensen, No. 151, has fruits very similar in shape to those of some forms of *E. siderophloia.*

3. xE. KALANGADOOENSIS Maiden and Blakely, n. sp.

(It is suggested that this may be a hybrid, of which *E. rubida* may be a parent.)

Arbor alta cortice lævi; foliis maturis alternatis petiolatis angustis vel latiusculo-lanceolatis, leniter undulatis supra subtusque nitentibus, 8-14 cm. longis, 1.5-3 cm. latis; venatione

* "Crit. Rev." is a contraction of Maiden's "A Critical Revision of the Genus Eucalyptus".

distincta, venis lateralibus e costa 30-40° orientibus; inflorescentia in umbellis simplicibus et axillaribus, pedunculo 10.15 mm. longo, 4-10 flores subsessiles ferentes; calyce turbinato operculo rostrato æquilongo; antheris versatilibus paralleliter dehiscentibus; disco florale interiorem atro-carnosam calycis tubi formante et ad ovarii basin extendente; fructibus turbinatis vel semiovatis disco distincto coronato et 3-5 valvis acutis valde exsertis.

A tall tree, with a smooth bark (Prof. J. B. Cleland, M.D., and Dr. J. A. Rolland).

Juvenile leaves not seen in the earliest stage, but two in the opposite stage on a fruiting branch are shortly petiolate, broadly lanceolate, obtuse, coriaceous, glossy on both sides, 8 cm. long, 4-5 cm. broad, the margin slightly thickened. Venation prominent, the lateral veins few and distant, making an angle of 35-45 degrees with the midrib; intramarginal vein distinct and distant from the edge.

Mature leaves alternate, petiolate, narrow to broadish-lanceolate, shortly acute to acuminate, somewhat undulate, glossy on both sides, 8-14 cm. long, 1.5-3 cm. broad. Venation distinct, intramarginal vein distant from the edge, lateral veins making an angle of 30-40 degrees with the midrib.

Inflorescence in simple axillary umbels, the 10-15 mm. peduncle bearing 4-10 shortly pedicellate flowers. Buds 10-12 mm. long, 5-7 mm. in diameter; calyx turbinate, about the same length as the rostrate operculum. Anthers versatile, opening in long parallel slits, the broad dorsal gland about half the length of the anther. Floral disc forming a dark carnose lining around the inner portion of the calyx-tube and extending to the base of the ovary, the ovary itself conical and slightly exceeding the rim of the calyx-tube in the newly spent flowers.

Fruit turbinate to semi-ovate, crowned by a well defined disc, and 3-5 acute white valves protruding well beyond it, 10 mm. long, 7-8 mm. in diameter. Capsular disc thick,

convex, extending about half-way over the valves, but quite free from them, the rim of the calyx-tube and the staminal ring usually well defined at the base of the disc.

Range.

This species has been found only in South Australia, near the township of Kalangadoo, which is situated between Grey Town and Kongart, and close to Mt. Burr.

Affinities.

1. With *E. viminalis* Labill., described in "Crit. Rev.," Part xxviii., p. 167, from which it appears to differ mainly in the apparently broader juvenile leaves, larger and more rostrate buds, and in the considerably larger and more turbinate fruit, with its thicker and more uniform disc. In typical *E. viminalis* the buds are in threes, but there are sometimes as many as six in the multi-flowered form. In the present species ten seems to be the greatest number, and they are much larger than any of the buds of the multi-flowered form of *E. viminalis* that we have seen so far.

2. With *E. rubida* Deane and Maiden, figured in "Crit. Rev.," Part xlix., p. 268. The affinity with this species appears to be in the broad juvenile leaves and in the nature of the bark and timber. But as we have not seen a good set of juvenile leaves of *E. Kalangadooensis*, a proper comparison in this direction is not possible at present.

3. With x*E. McIntyrensis* Maiden, vide "Crit. Rev.," Part liv., p. 166. Both species no doubt have much in common in general appearance, also in the nature of the bark and in the adult leaves, and possibly in the juvenile leaves, and also to some extent in the buds and fruits. The buds are, however, much smaller in *E. McIntyrensis*, also the fruits, which are more hemispherical.

4. E. MICRONEURA Maiden and Blakely, n. sp.

Arbor parva, cortice Box simili, ramulis gracilibus pendulis; foliis junioribus non visis; foliis maturis parum glaucis supra subtusque obscuris angusto-v. lato-lanceolatis tenuissimis, marginibus undulatis 8-16 cm. longis, 1-2.5 cm. latis; petiolis teretibus 1.5-2.5 cm. longis, venis tenuissimis, parum conspicuis, venis lateralibus e costa 40-45° orientibus, vena peripherica margini approximata; inflorescentia terminali paniculata 3-6 cm. longa vel longiore, pedunculo umbellarum singularum tereti 3-5 flores pedicellatos ferente; alabastris glaucis parum ellipticis 5-6 mm. longis, 3 mm. diametro; operculo calycis tubo campanulato paulo longiore; antheris semi-terminalibus; fructu turbinato v. campanulato pedicellato obscure 2-3-costato, 5-6 mm. longo, apice 5-6 mm. lato; valvis brevibus latis, apicibus parum exsertis.

A small tree with a Box-like bark and slender drooping glaucous leaves and branchlets.

Juvenile leaves not seen.

Mature leaves slightly glaucous and dull on both sides, narrow to broadish lanceolate to falcate lanceolate, acuminate, very thin with slightly undulating margins, 8-16 cm. long, 1-2.5 cm. broad, petioles terete and slender, 1.5 to 2.5 cm. long. Venation very fine, almost invisible, the midrib depressed or channelled above, prominent beneath, the lateral veins making an angle of 40-50 degrees with the midrib; intramarginal vein close to the edge.

Inflorescence a terminal panicle, 3 to 6 cm. long or longer, the common peduncle of each umbel terete, about 1 cm. long, supporting 3 to 5 distinctly pedicellate flowers. Buds glaucous, somewhat elliptical, acute, 5 to 6 mm. long, about 3 mm. in diameter, the operculum slightly longer than the campanulate, faintly ribbed calyx-tube. Anthers semi-terminal. Floral disc obscure, represented by a thin, dark membrane, lining the shallow calyx-tube, and extending over the convex ovary.

Fruit turbinate to campanulate, pedicellate, faintly 2 or 3 ribbed, 5-6 mm. long, about 5 mm. broad at the top, truncate, 3-4 celled, the valves short and broad, with the tips sometimes slightly protruding. Capsular disc thin, forming with the staminal ring a slightly thickened oblique rim over the top of the capsule.

The type is C. T. White, No. 1385, February, 1922, and his No. 1384 may be taken as a co-type.

Range.

So far as we know at present, it is confined to Northern Queensland, for it has been collected only on the Gilbert River; "very abundant, Box-bark" (C. T. White, No. 1385, February, 1922); "small trees, Box-bark," Forsayth (Etheridge Railway), North Queensland (C. T. White, No. 1384, same date).

Affinities.

1. With *E. Spenceriana* Maiden. See Part xxxviii., p. 206, Plate 156, "Crit. Rev." Both species are Boxes with a hard, more or less deeply furrowed bark, but the colour of the timber of *E. microneura* is unknown, while that of *E. Spenceriana* is a dark red. The leaves of both species are very much alike as regards venation and texture, but those of *E. Spenceriana* are not glaucous; other characters, such as the anthers and the fruit, are also dissimilar to those of *E. microneura*.

2. With *E. microtheca* F.v.M., figured in Part xi., p. 51, Plate 52, "Crit. Rev." This is also a Box with a wide northern range, and in cortical characters it resembles *E. microneura* and *E. Spenceriana*, which is also a northern species. The leaves of *E. microtheca*, like those of *E. microneura*, are more or less glaucous, but · the venation is coarser in the former, and the fruits are small and very different from those of *E. microneura*.

3. With *E. Whitei* n. sp. Some of the fruits of *E. Whitei* resemble those of *E. microneura,* and the leaves of both are more or less glaucous. *E. Whitei* is, however, an Ironbark, and not only does it differ from *E. microneura* in the bark, but also in buds and anthers, as well as in the venation and texture of the leaves. Both species are found at no great distance from each other, and they may eventually be found in close association.

5. xE. WESTONI Maiden and Blakely, n. sp.

(Suggested to be a hybrid, of which *E. maculosa* R. T. Baker may be a parent.)

Arbor mediocris, ramis patentibus, cortice lamellosa vel sub-fibroso cinereo; ligno pallido albescente vel carneo; foliis junioribus crassiusculis subglaucis supra subtusque, inferioribus foliis oppositis sessilibus angusto—vel lato—oblongis, 3-6 cm. longis, 8-20 mm. latis; venis prominentibus, venis secundariis e costa 30-40° orientibus; vena peripherica a margine remota; foliis maturis crassiusculis petiolatis angusto-lanceolatis vel falcato-lanceolatis, 10-17 cm. longis, 1-1.5 cm. latis; venis modice distinctis, venis secundariis e costa 30-45° orientibus, vena peripherica margini approximata; inflorescentia axillari; alabastris 5-7 in capitulo, cylindraceis 8-9 mm. longis; operculo acuto conoideo 3 mm. longo; antheris versatilibus oblongis longitudinaliter aperientibus; fructibus campanulatis 7 mm. longis, 5-6 mm. diametro, valvarum brevium et crassarum apicibus albis calycis marginem excedentibus.

A medium-sized tree with spreading branches, rough barked to the small branches, rough or slightly flaky to sub-fibrous, greyish. Timber pale, whitish to pinkish, dries pale; not tough.

Juvenile leaves somewhat thick, drying the same colour on both sides, the lower ones opposite, sessile, narrow to broad-oblong, the margins slightly undulate, 8 to 20 mm. broad, 3 to 6 cm. long, veins fairly prominent, the intramarginal vein distant from the edge, the secondary veins making an angle of 30 to 40 degrees with the midrib.

Mature leaves thickish, petiolate, narrow-lanceolate to falcate-lanceolate, and with a long acuminate point, 1 to 1.5 cm. broad, 10 to 17 cm. long, the intramarginal vein close to the edge, the secondary veins making an angle of 30 to 45 degrees with the midrib.

Inflorescence axillary, the umbels on slightly compressed peduncles about as long as the buds. Buds 5-7 in the head, cylindrical, or gradually tapering into the thick, short pedicel, 8-9 mm. long, somewhat glossy, the operculum acute, conoidal, the lower portion slightly thicker than the calyx-tube, 3 mm. long. Calyx-tube cylindrical to slightly campanulate, 4 mm. long, the pedicel 2 mm. long. Anthers versatile, somewhat similar to those of *E. maculosa.* Floral disc forming a thickish covering around the top of the calyx and projecting a short distance over the ovary.

Fruit campanulate, 7 mm. long, 5 to 6 mm. in diameter, thickish, the short thick, white-tipped valves protruding beyond the calyx rim. Capsular disc forming a truncate or domed rim on the top of the capsule, the inner margin free from the valves, and sometimes exceeding the staminal ring, which is nearly always present on the mature fruit.

In honour of Thomas Charles George Weston, formerly of the Botanic Gardens sub-department, Sydney, and for some years past Afforestation Officer of the Federal Territory at Canberra, a competent hybridist, cultivator and forester.

Range.

Found so far only on the Yass-Queanbeyan Road, near Gungahleen, Federal Territory (C. Weston), an area carved out of Southern New South Wales.

Affinities.

1. With *E. maculosa,* R. T. Baker. It bears a very strong resemblance in buds, fruits and mature leaves, but

it is distinct in its cortical character. The bark of *E. maculosa* is smooth and blotched, while the bark of *E. Westoni* is rough and slightly flaky to sub-fibrous, greyish, somewhat after the colour of *E. hemiphloia*. The seedling of *E. maculosa* is much broader than that of *E. Westoni*. The latter may be described as narrow and rigid.

We suggest that perhaps it may be a hybrid of which *E maculosa* is one of the parents. Mr. Weston, the discoverer of the plant, and one of the present writers found only two trees, but this is often the case with a reputed hybrid until after prolonged search.

2. With *E. viminalis*, Labill., in the shape of the buds, and also in the shape of the fruits. These characters, however, are in threes in *E. viminalis* typica, but when the multi-flowered form is compared with *E. Westoni*, the affinity is even more apparent. *E. viminalis* also has rough bark at the base, but not so fibrous, nor so persistent up the trunk as in *E. Westoni*.

6. E. Whitei Maiden and Blakely, n. sp.

Ironbark parva; cortice alte sulcato atro-cinereo; ligno pallide-rubro duro; foliis junioribus lato-oblongis crassiusculis glaucis; foliis maturis petiolatis oblongo-lanceolatis vel falcato-lanceolatis, 7-13 cm. longis, 1.5-2 cm. latis, venis indistinctis, venis secundariis e costa 30-40° orientibus; inflorescentia axillari umbellis 5-7 floris, pedunculo communi 7-10 mm. longo, pedicellibus gracilibus·4-5 mm. longis; alabastris plerumque operculo brevi acuto calycis tubo ca equilongo; antheris lato-ovatis per fissuras laterales aperientibus; loculamentis magnis; fructibus glaucis semi-ovatis vel leniter campanulatis truncatis aliquando apice leniter contracto 5-7 mm. longis ca 5 mm. diametro; valvis leniter exsertis vel inclusis.

A small Ironbark of glaucous appearance, with a rather deeply-furrowed dark grey bark, deepening to lead coloured. Timber (only one small specimen seen) inclined to pale red, close grained and very hard.

Juvenile leaves. Those available are not very satisfactory. They are inclined to broadish oblong, are obtuse, shortly petiolate, moderately thick and glaucous, more or less undulate, 7-8 cm. long, 2 cm. broad. Intramarginal vein close to the edge, venation somewhat obscure, the secondary veins making an angle of 35-45 degrees with the midrib.

Mature leaves petiolate, thickish, moderately glaucous, dull, the same colour on both sides, oblong-lanceolate to falcate-lanceolate, 7 to 13 cm. long, 1.5 to 2 cm. broad, intramarginal vein very close to the edge, venation indistinct, the secondary veins making an angle of 30-40 degrees with the midrib.

Inflorescence axillary, or occasionally somewhat racemose, 5 to 7 in the umbel, the common peduncle slender, slightly compressed to almost terete, 7-10 mm. long, the pedicels slender, 4-5 mm. long. Buds usually elongated, with a short acute operculum about the same length as the calyx-tube; in some forms it is shorter. Anthers broadly ovate with lateral slits, the cells large, also the dorsal gland. Floral disc represented by a very thin membrane lining the calyx-tube.

Fruit glaucous, semi-ovate to somewhat campanulate, truncate, usually 4-celled, sometimes slightly contracted at the top, and gradually tapering into the slender pedicel; valves short and broad, slightly exserted or enclosed, 5-7 mm. long, about 5 mm. in diameter. Capsular disc somewhat obscure, usually represented by a slight thickening of the discal lining at its junction with the somewhat persistent staminal ring. In common with the Ironbarks and Boxes, the capsular disc of this species is not very well developed.

The name proposed is in honour of Cyril Tenison White, Government Botanist of Queensland, whose distinguished services to the botany of his State are well known.

Range.

It is confined to Northern Queensland, so far as we know at present. Following are localities:—

Burdekin River, an old specimen from F. Mueller, mixed with *E. crebra;* at 1400 feet, Prairie, 30 miles east of Hughenden. An Ironbark looked upon as a large-fruited form of *E. crebra.* Mature leaves (which are more or less glaucous) and fruits alone available, but it appears to be fairly typical of the species (R. H. Cambage, No. 3955, 1913); Berricania, Central Queensland, on the road between Muttaburra and Prairie. A small Ironbark (C. T. White, April, 1919); Tower Hill, small Ironbark, very common (No. 16, same collector and date); common about Berricania. J. S. Swanson, September, 1920 (C. T. White, No. 17); "Ironbark," with slightly smaller fruits, The Plains, Prairie (J. R. Chisholm, August, 1920).

Affinities.

1. With *E. Staigeriana* F.v.M., the "Lemon Scented Ironbark," see Part xii., p. 69, "Crit. Rev." Both species have glaucous foliage, but the leaves of *E. Staigeriana* are usually broader and shorter, and strongly lemon-scented, while the fruits are also smaller and slightly different in shape.

2. With *E. drepanophylla* F.v.M. See Part xlix., p. 262, "Crit. Rev." The leaves of both species are thickish, but the glaucousness of *E. Whitei* readily distinguishes it from *E. drepanophylla.* It also differs from the latter species in the inflorescence, which is usually axillary, or when terminal, consisting of 2-4 umbels, and in the shape of the fruit.

3. With *E. crebra* F.v.M. See Part xii., p. 63, "Crit. Rev." Both species are typical Ironbarks, but *E. crebra*, even in districts where both species are found, appears to be a much larger tree with thinner and greener leaves and smaller buds and fruits.

4. With *E. Culleni*, R. II. Cambage. See Part xlviii., p. 233, "Crit. Rev." This is also a medium-sized Ironbark, and is probably a slightly larger tree than *E. Whitei*, with thin, green leaves, and somewhat globose fruits, with the valves well exserted, and with a more strongly developed capsular disc than that of *E. Whitei*.

7. E. ALBIDA Maiden and Blakely, n. sp.

Mallee parva 2-6ft. alta, caulibus tenuibus e basi lignea orientibus, cortice tenui rubro-brunneo; foliis junioribus tenuibus glaucis sessilibus cordatis vel ellipticis mucronatis 12-27 mm. longis, 12-22 mm. latis, plurimis paribus oppositis; venatione mediocriter distinctis, venis secundariis e costa 45-60° orientibus, vena peripherica margini approximata; foliis maturis tenuibus pallido-viridibus utrimque nitentibus, petiolatis, oblongis vel angusto-lanceolatis, 4-7 cm. longis, 5-10 mm. latis; venatione distincta, venis secundariis e costa 40-45° orientibus, vena peripherica margini approximata; inflorescentia axillari, pedunculo communi flores 5-7 distincte pedicellatos ferentes; alabastris clavatis 4 mm. longis, operculo obtuso calycis tubo æquilongo; antheris adnatis per poros semi-terminales dehiscentibus; style gracili persistente apice torta; fructibus semi-ovatis, truncatis 3-4 mm. longis, valvarum trium apicibus acutissimis e margine capsulae exsertis.

A dwarf Mallee of 2 to 6 feet in height, stems thin, straggling, from a woody stock, the bark thin, warm red or reddish-brown, with small purple patches of bark when collected.

Juvenile leaves thin, conspicuously glaucous, sessile to slightly stem-clasping, opposite for an indefinite number of pairs, the lowest pairs orbicular, emarginate, oblong, cordate to elliptical, the upper ones usually mucronate or

acuminate at the apex, 12-27 mm. long, 12-22 mm. broad. Venation moderately distinct, the secondary veins making an angle of 45-60 degrees with the midrib; intramarginal vein almost obscure and usually very close to the edge.

Intermediate leaves glaucous, alternate, sessile to very shortly petiolate, oblong to broadly lanceolate, with a short acuminate point, 27-60 mm. long, 18-28 mm. broad. Venation distinct, the secondary veins making an angle of 45-60 degrees with the midrib; intramarginal vein somewhat distant from the edge.

Mature leaves thin, light green and shining on both sides, petiolate, oblong to narrow-lanceolate, often with a long point, 4-7 cm. long, 5-10 mm. broad. Venation distinct, the secondary veins making an angle of 40-45 degrees with the midrib; intramarginal vein confluent with the nerve-like margin.

Inflorescence axillary, the common peduncle slender, slightly compressed, supporting 5-7 distinctly pedicellate flowers. Buds, including the pedicels, 8-10 mm. long, clavate or nearly so, operculum obtuse, conical, about the same length as the calyx-tube. Anthers (immature) adnate, opening in semi-terminal pores or on the shoulders with a small terminal gland between them. Style somewhat persistent, slender, spirally twisted at the top, developing with the capsule and eventually splitting at the base into three needle-like divisions when the capsule ripens. Floral disc forming a dark lining around the inside of the calyx-tube and apparently free from the top of the ovary.

Fruit shortly campanulate to semi-ovate, truncate, 3-4 mm. long, 4 mm. in diameter at the top, valves free with very fine points protruding well beyond the rim of the fruit. Seeds not seen. Capsular disc slightly thickened, usually exceeding the rim of the calycine ring.

The proposed name "albida, inclining to white," is in allusion to the juvenile foliage.

Range.

Only known at present from Western Australia, at Harrismith, on rises, in sandy or sandy-gravelly soil (C. A. Gardner, No. 2113, 6th March, 1924).

Affinities.

1. With *E. uncinata,* Turcz., described in "Crit. Rev.," Part xiv., p. 143, and Part lvi., p. 262.   This proposed new species appears to be its closest affinity, especially in the shape of the juvenile leaves, but those of *E. uncinata* are much thicker and greener.   The adult leaves are also thicker and more rigid (often very rigid), while the buds and fruits are sessile and more numerous in the umbel and also quite different in shape.   The white juvenile leaves appear to be a distinctive feature of the proposed new species.   They are as white as those of *E. globulus* and *E. rubida.*

2. With *E. leptophylla* F.v.M., figured in "Crit. Rev.," Part lvi., p. 259.   It seems to have the general appearance of this species, but the mature leaves are broader and less rigid, while the juvenile leaves are very glaucous and twice as broad as those of *E. leptophylla.*   The buds and fruits are also somewhat similar in both species; they are pedicellate, but the operculum of *E. leptophylla* is nearly always more or less rostrate, and the fruit is thick with scarcely exserted valves.

3. With *E. angusta,* Maiden, described in "Crit. Rev.," Part lvi., p. 265.   The mature leaves of both species are very much alike, but those of *E. angusta* are thicker and more rigid.   Both species are also closely allied in the anthers, but the buds and fruits of *E. angusta* are coarser and different in shape from those of *E. albida.*

8. E. BURRACOPPINENSIS Maiden and Blakely, n. sp.

Arbor parva vel frutex 8-15 feet altus, cortice basi rugoso, ramis lævibus, folia juniora non vidimus; foliis maturis alternatis, crassiusculis, dilute viridibus, petiolatis, angustis ad lato-lanceolatis, 8-12 cm. longis, 1-3 cm. latis, venis tenuissimis leniter obscuris; venis lateralibus numerosis 30-40° e costa orientibus, vena peripherica margini approximata; inflorescentia axillari, pedunculo cum 3 floribus grandiusculis pedicellatis alabastris pyriformibus, 3 cm. longis, 1.5-2 cm. diametro; operculo crasso rostrato, 1.5-2 cm. longo, basin versus leniter vel distincte costato; calycis tubo hypocrateriformi, lævi vel obscure costato; antheris magnis latis paralleliter aperientibus; fructu depresso-turbinato, lævi vel leniter costato, parte calycem versus lævi, parte discali crassa annulum staminalem multo excedente, valvis crassis deltoideis acutis leniter exsertis.

A small tree or shrub, 8-15 feet high, with smooth grey bark on the branches, and the lower part of the trunk covered with ragged bark (Max Koch).

Juvenile leaves not seen.

Mature leaves alternate, moderately thick, light green, petiolate, narrow to broad lanceolate, the apex acuminate-uncinate, 8-12.5 cm. long, 1-3 cm. broad, petiole compressed, expanded upwards, 1.5-2 cm. long; venation very fine and somewhat obscure on both surfaces, the midrib channelled above, and scarcely raised beneath; lateral veins numerous, making an angle of 30-40° with the midrib, intramarginal vein close to the edge.

Inflorescence axillary, the common peduncle bearing three moderately large pedicellate flowers. Buds somewhat pyriform, 3 ·cm. long, 1.5-2 cm. in diameter. Operculum very thick, rostrate, 1.5-2 cm. long, faintly or distinctly many ribbed at the base and more inflated than the calyx; calyx-tube funnel-shaped, gradually diminishing into the terete pedicel, smooth, or with a few faint ridges, 8-10 mm. long; anthers large and broad, opening in parallel slits.

Floral disc pale-coloured, conspicuously raised above the top of the ovary, as in *E. pyriformis,* and forming a deep nectary around the ovary.

Fruit depressed-turbinate, the thick calycine portion smooth and glossy, slightly ribbed, the discal portion also thick, much paler than the former, and considerably raised above the staminal ring; valves four, thick, deltoid, acute, slightly exsert. Capsular disc pale-coloured, rather broad and thick, and much raised above the sharp rim of the calyx, the sides sloping upwards to a broadish truncate rim, the inner surface of the rim slightly oblique, the entire disc free from the valves of the capsule. The morphosis of the disc is similar to that of *E. pyriformis* and the variety *Kingsmilli* depicted in Part lxi., Plate 250, figs. 1a to 2c, of "Crit. Rev."

<div align="center">Range.</div>

It is known only from Western Australia. Localities are: Burracoppin, F. M. C. Schock, No. 205, 2nd July, 1917; Dr. J. B. Cleland, 1908, figured in Part xvii., Plate 75, figs. 7a, 7b (mature leaf and fruit), as *E. pyriformis* Turcz. var. *minor,* see also Part xli., p. 17 ("Crit. Rev."). Half-way between Booran Siding and Burracoppin, F. M. C. Schock, 2nd July, 1917. Small tree, upper branches with a smooth grey bark, the lower part of trunk covered with ragged bark. Merredin, Max Koch, No. 3020, January, 1924. In fruit and very young buds; the latter, although immature, show the corrugation.

"A shrub with the habit of typical *E. Oldfieldi,* with the stems densely branched from near the base, erect and spreading, 8-15 feet high. Flowers yellowish-white; bark silver-brown, with a rough dark grey persistent bark at the base." Carrabin, Westonia Road, in yellow sandy soil on plains, or in thickets of *Hakea multilineata* and *Casuarina acutivalvis.* Flowers October-November (C. A. Gardner, No. 1825, 7th October, 1922, Co-type).

Affinities.

1. With *E. pyriformis* var. *Rameliana,* Maiden. See Part xvii., p. 232 ("Crit. Rev."). This is an imperfectly known variety, and it seems to have the same funnel-shaped calyx-tube as *E. Burracoppinensis,* but the operculum is quite smooth, not corrugated, as in the new species.

2. With *E. Oldfieldi* F.v.M., figured in Part xvii., p. 223, and again referred to in Part xli., p. 21 ("Crit. Rev."). Both species appear to be much alike in habit; they are Mallee-like or occasionally developing as individual trees. There is also a great deal of similarity between them in the shape of the fruits, but generally the fruits of *E. Oldfieldi* are smaller and invariably sessile. But the large rostrate, corrugated operculum, and the large parallel anthers of *E. Burracoppinensis* readily separate it from *E. Oldfieldi.*

3. With *E. pachyphylla* F.v.M., depicted at Part xli., p. 12 ("Crit. Rev."). The fruits appear to be the only character which bring these species together. They are both members of the *E. pyriformis* series with the typical *pyriformis* fruit, which show the large raised disc perhaps better than any other species. The fruits of *E. pachyphylla* are, however, more strongly ribbed than the fruit of *E. Burracoppinensis.*

9. E. CYLINDRIFLORA Maiden and Blakely, n. sp.

Mallee caulibus erectis e trunco columnæ basi simili orientibus, 10-15 feet alta, 3-5 inches diametro, cortice tenui, albo, pulvereo cortice fracto viridi, ligno pallide brunneo; foliis junioribus, primis 3-4 paribus oppositis, spathulatis vel oblongis, breviter petiolatis, obscure viridibus, 4-5.5 cm. longis, 1.5-2.5 cm. latis, venis inconspicuis, venis secundariis e costa 35-50° orientibus, vena peripherica a margine remota; foliis maturis alternatis lævibus supra subtusque nitentibus, angusto-lanceolatis in petiolum breve angustatis 5-8 cm. longis, 5-10 mm. latis; venis inconspicuis, venis lateralibus e costa 30° orientibus, vena peripherica margini approximata; inflorescentia axillari vel aliquando semi-

terminali, umbellis pedunculatis 3-6 floris, filamentis albis, alabastris pedicellatis cylindraceis 1.5 cm. longis, diametro 5-7 mm.; operculo conico obtuso calycis tubo semiovato æquilongo; antheris majusculis oblongo-ovatis, longitudinaliter aperientibus; fructibus breviter cylindraceis vel semiovatis truncatis trans apicem 1 cm. longis, 7 mm. latis, annulo staminali vix dilatato coronatis; valvis parvis inclusis.

"White Mallee." Habit of *E. erythronema,* but slightly less robust. Stems erect from a broad, pedestal-like stock, 10-15 feet high and 3-5 inches diameter. Bark thin, white, powdery, green in fracture. Timber light brown, dense and very hard. Flowers white (no red flowers seen). Bendering, on loam flats, with *Melaleuca uncinata.* Flowers in January (C. A. Gardner, No. 1909, February, 1923).

Juvenile leaves. Only the first 3-4 pairs opposite, spathulate to oblong, shortly petiolate, pale, or a very dull green when dry, 4-5.5 cm. long, 1.5-2.5 cm. broad; venation not conspicuous, the secondary veins making an angle of 35-50 degrees with the midrib; intramarginal vein distant from the edge.

Mature leaves alternate, smooth and shining on both surfaces, narrow-lanceolate to lanceolate-falcate, narrowed into a short petiole, 5-8 cm. long, 5-10 mm. broad; venation obscure, lateral veins making an angle of 30 degrees with the midrib; intramarginal vein close to the edge.

Inflorescence axillary or sometimes appearing semi-terminal, the peduncle bearing an umbel of 3-6 white flowers. Buds cylindrical, about 1.5 cm. long, 5-7 mm. in diameter. Operculum conical, obtuse, about the same length as the semi-ovate calyx-tube; the pedicels are also about the same length. Anthers rather large, oblong-ovate, slightly emarginate with a long dorsal gland. Floral disc forming a slightly thickened layer around the calyx-tube and extending over the sunken ovary.

Fruit shortly cylindrical or somewhat semi-ovate, trun-
cate, crowned by the scarcely enlarged staminal ring, 1 cm.
long, 7 mm. across the top, the pedicels about 1 cm. long,
valves small, well enclosed. Capsular disc not conspicuous,
forming with the staminal ring an oblique, slightly thick-
ened band around the inside of the capsule and extending
nearly half-way over the free valves.

The name proposed is in reference to the shape of the
buds.

Range.

Confined to Western Australia, so far as we know at
present. Found at Bendering, on loam flats, with *Melaleuca
uncinata* (C. A. Gardner, No. 1909). Bendering is on the
railway line from Narrogin to Naremburn, and about 120
miles east of Perth.

Affinities.

1. With *E. erythronema,* Turcz., depicted in Part xxii.,
p. 23, "Crit. Rev.", from which it differs in the white
filaments, in the more cylindrical, somewhat thin, smooth
fruits, and in the shape of the calyx-tube, which is not
expanded at the top as is the case with *E. erythronema;*
also in the somewhat obscure disc, as against the con-
spicuous disc of *E. erythronema.* The fruit of that species
is broadly turbinate and crowned by a broad, sharp disc,
and with the valves of the capsule protruding well beyond
it. In *E. cylindriflora* the disc is obscure and the valves
are well enclosed in the capsule, and they do not protrude
beyond the small disc. The anthers of the present species
appear to differ from those of *E. erythronema;* they are
more emarginate and the dorsal gland is more attenuated.
The only juvenile leaves we have seen of *E. erythronema*
are from a cultivated plant, and they are narrower and
smaller than those of *E. cylindriflora.*

2. With *E. eremophila,* Maiden. The shape of the fruits
is similar in both species, but those of *E. eremophila* are
thicker, and the staminal ring which forms the disc is much
larger; it sometimes extends over the top of the fruit. The
fruits of *E. cylindriflora* are thin and the staminal ring
very narrow.

10. E. Desmondensis Maiden and Blakely, n. sp.

Frutex gracilis glaucus 10-15ft. altus, ramulis longis flexuosis
pendulis, caulibus ad 4ih. diametro, cortice laevi albo pulvereo;
foliis junioribus non visis, foliis maturis petiolatis oblongis vel
lanceolatis, crassis, supra subtusque glaucis, 6-11 cm. longis,
12-25 mm. latis: venatione obscura, venis lateralibus e costa
40-50° orientibus; vena peripherica a margine incrassata re-
mota; inflorescentia axillari, pedunculo plano 15-19 mm. longo,
5 mm. lato superiore paite; pedicellis fere absentibus, alabastris
fere infundibuliformibus, operculo acuto longioribus; antheris
versatilibus oblongis late paralleliter dehiscentibus glandula
magna; styie fere quadrangulari; stigma parva disco simili;
fructibus non visis.

A slender, glaucous shrub, with long flexuose drooping
branches, 10-15 feet high, the stem up to 3 or 4 inches in
diameter. Bark smooth, almost white, and powdery almost
to the ground (C. A. Gardner).

Juvenile leaves not seen. They will, without doubt, be
more glaucous and broader than the mature ones.

Mature leaves alternate, petiolate, oblong to lanceolate,
thick, glaucous on both surfaces, 6-11 cm. long, 12-25 mm.
broad. Venation somewhat obscure, lateral veins forming
an angle of 40-50 degrees with the midrib, the intramar-
ginal vein distant from the somewhat thickened margin.

Inflorescence axillary, the peduncle strap-shaped, dilated
upward into a broadish disc under the flowers, 15-19 mm.
long, 5 mm. broad in the broadest part. Buds nearly
sessile, almost cylindrical, 7-15 in the head. Calyx-tube
somewhat funnel-shaped, longer than the pointed and

slightly rostrate operculum.   Filaments cream-coloured.
Anthers versatile, oblong, opening in broad parallel slits,
the dorsal gland large, not exceeding the cells at the top.
Style almost quadrangular; stigma small, disc-like.

Fruits not seen.

Range.

Only known at present from Western Australia.   Des-
mond, near Ravensthorpe, near Hopetoun, in sandy, stony
soil, on rising ground or ridges (C. A. Gardner, No. 2183,
May, 1924).

Affinities.

In the absence of fruits and juvenile leaves, the position
of this plant cannot be stated with certainty, but it appears
to be new.

1. With *E. accedens* W. V. Fitzgerald.   Differs from
this species in size (it seems to be a small shrub or tree),
in perhaps greater glaucousness, more sessile buds, longer
and broader common peduncle, and in the more pointed
operculum, also in habit.

2. With *E. redunca* Schauer.   It is very close to this
species, but the habit and inflorescence are quite different
(C. A. Gardner).

3. With *E. sepulcralis* F v M.   The species has much
the habit of *E. sepulcralis*, but has greener leaves (C. A.
Gardner).

11. E. DONGARRAENSIS Maiden and Blakely, n sp.

White Gum parva, Mallee similis, 20-25 feet alta; foliis juniori-
bus leniter glaucis lato-ellipticis ad ovatis, petiolatis 3.5-8.5 cm.
longis, 3.5-6.5 cm. latis; venis mediocriter distinctis, vena peri-
pherica a margine remota, venis lateralibus remotis e costa 45°
orientibus; foliis maturis crassis pallide viridibus obscuriusculis
angusto vel lato-lanceolatis 7.5 cm.—12 cm. longis, 1.5-3 cm.
latis; venis obscuris e costa 45° orientibus; inflorescentia axil-
lari, pedunculis compressis floribus breviter pedicellatis 5-9

capitulo; alabastris glaucis clavatis; operculo hemispherico calycis tubo turbinato breviore; fructibus pyriformi-cylindraceis truncatis 10 mm. longis, 6 mm. latis 4-locularibus valvis insertis.

A slender White Gum, ribbony at the butt, 20-25 feet high, with a trunk 4 inches in diameter. Wood very tough, a little brown at heart. (Only one clump was seen, and a fuller note will be found below.)

Juvenile leaves broadly ovate to ovate-elliptical, with a rather long, semi-terete peduncle, 3.5 to 8.5 cm. long, 3.5 to 6.5 cm. broad, slightly glaucous (the somewhat compressed internodes very glaucous), rather thick and rough, with numerous slightly raised oil-glands, and minute reticulate veins. Venation moderately distinct, intramarginal vein distant from the edge, lateral veins rather distant, forming approximately an angle of 45 degrees with the midrib; midrib prominent beneath, indistinct above.

Intermediate leaves slightly glaucous, broadly cordate-lanceolate to obliquely lanceolate, a few rounded-deltoid, 5-9 cm. long, 5-7.5 cm. broad, the petiole terete, sometimes exceeding 2 cm. long. Venation moderately distinct, intramarginal vein somewhat wavy, and here and there 3-4 mm. from the edge, lateral veins making an angle of about 45-50 degrees with the midrib.

Mature leaves thick, pale green, dull, narrow to broad-lanceolate, 7.5 to 12 cm. long, 1.5 to 3 cm. broad, venation obscure, the intramarginal vein usually confluent with the edge, lateral veins obscure, making an angle of about 35-40 degrees with the midrib.

Inflorescence axillary, the common peduncle compressed, gradually expanding upwards, 10-15 mm. long, supporting a head of 5-9 flowers on short, thick pedicels. Buds glaucous, clavate, including the pedicel, 11 mm. long; operculum hemispherical, often with a small umbo, many

times shorter than the calyx-tube, wrinkled and more or
less ribbed, about 4 mm. in diameter. Anthers ovate-
emarginate, opening in longitudinal slits, with a prominent
dorsal gland. Floral disc forming a thin, dark, carnose
lining around the calyx-tube, and extending for a short
distance over the top of the ovary, which is much paler
in colour.

Fruit pyriform to cylindrical, truncate, gradually
diminishing into the short, thick pedicel; 10 mm. long, 6
mm. broad, the rim sharp and sloping inwards, 4-celled,
the valves rather short, all enclosed. Capsular disc form-
ing with the staminal ring a slightly thickened oblique
band around the inner rim of the calyx-tube; staminal
ring present. Seeds not seen.

Range.

It has been seen only at Dongarra, in Western Australia,
up to the present. Dongarra is a railway station on the
coast, 275 miles north of Fremantle and 43 miles south of
Geraldton.

In Part xxxviii., p. 222 of his "Crit. Rev.," under *E.
dumosa*, Mr. Maiden gave the following statement from his
notebook, made in 1909, when standing in front of the
trees :—"At Dongarra, not far from the beach, is a dense
growth of slender White Gums, ribbony at butt, which
reminds one of dense Mallee, but not true Mallee, 20-25
feet high, trunk 4 inches diameter. Wood very tough, a
little brown at heart. Operculum a little ribbed. Broad,
coarse suckers; glaucous buds. It is very close to the
typical *incrassata*, certainly a connecting link."

Affinities.

1. With *E. dumosa*, A. Cunn. See Part xxxviii., p. 220,
"Crit. Rev." It seems to be more of a White Gum than
E. dumosa, and perhaps a somewhat larger type of Mallee,

but this is not certain. It is also more glaucous, especially in the juvenile leaves and buds. The operculum is also shorter, and the fruit larger and more pyriform.

2. With *E. conglobata* (R.Br.), Maiden. See Part iv., p. 100, also Part lvi., p. 274, "Crit. Rev." It seems to resemble *E. conglobata* in its Mallee-like habit, but the stems are straighter and whiter. The juvenile leaves of both species are glaucous, but those of *E. Dongarraensis* are considerably coarser. In buds and fruits both species are easily separated.

3. With *E. incrassata*, Labill., vide Part iv., p. 93, "Crit. Rev." The juvenile leaves and the anthers of *E. incrassata* and *E. Dongarraensis* are somewhat similar and they appear to be the only botanical characters upon which an affinity can be based. The juvenile leaves are, however, much broader and more glaucous than those of *E. incrassata*.

12. E. KESSELLI Maiden and Blakely, n. sp.

Frutex parvus Mallee similis; ramulis angularibus; folia juniora non vidimus; foliis maturis alternatis longe petiolatis crassis coriaceis olivan colore referentibus, utroque latere nitentibus, angusto vel lato-lanceolatis, 8-11 cm. longis, 2-2.5 cm. latis, petiolis 3.5 cm. longis; venis obscuriusculis, costa non prominente et utroque latere obscure striata, venis lateralibus tenuissimis e costa 30-40° orientibus, vena peripherica a margine remota; inflorescentia axillari, floribus tribus breviter pedicellatis pendulis; pedunculo compresso dilatato 2-2.5 cm. longo, media parte 4 mm. lato; alabastris statu perfecto non visis; antheris magnis leniter reniformibus; fructibus crassis turbinatis truncatis, 9-12 valdis costis circa apicem in pedicellum breve crassum angulare 15-18 mm. longum et apice equilatum, valvis acutissimis et valde exsertis.

A small Mallee-like shrub with somewhat angular branchlets.

Juvenile leaves not available.

Mature leaves alternate, on long petioles, thick, coria-
ceous, rather flat, olive-green and shining on both surfaces,
narrow to broad-lanceolate, 8 to 11 cm. long, 2-2.5 cm.
broad, the petioles up to 3.5 cm. long. Venation obscure,
the midvein slightly channelled on both surfaces, and
scarcely raised above the surface of the leaf; lateral veins
very fine, rising at an angle of 30 to 40 degrees to the
midrib; intramarginal vein removed a short distance from
the edge.

Inflorescence axillary, consisting of three shortly pedi-
cellate, drooping flowers, the common peduncle com-
pressed, dilated upwards, 2-2.5 cm. long, about 4 mm.
broad in the middle. Buds not seen, but, judging by the
length of the style, the operculum is rather long. Staminal
ring broadish, raised above the calyx-rim. Filaments
cream-coloured, inflexed in the bud. Anthers large, almost
reniform in shape and larger and broader than those of
E. goniantha; gland dorsal, large and globular.

Fruit thick, turbinate, truncate, with 9-12 strong corru-
gations around the top, which diminish into the short,
thick, angular pedicel, 15-18 mm. long and as broad at the
top. Valves usually four, with needle-like points protrud-
ing well beyond the top of the capsule, as in *E. oleosa* and
E. longicornis. Çapsular disc conspicuous, forming a
raised ring around the orifice, and slightly higher than the
elevated corrugations of the capsule.

In honour of Stephen Lackey Kessell, Conservator of
Forests of Western Australia, who has, during his period
of office, given every facility for the elucidation of the
flora of his State.

Range.

Known only from Western Australia. Found in sandy
loam in Mallee thickets at a place called Salmon Gums, 66

miles north of Esperance (W. P. Brown, per C. A. Gard-
ner, No. 944a; the type).

Affinities.

1. With *E. corrugata* Lueh., described in Part xvi., p.
198, "Crit. Rev." Both species are Mallees and have much
in common as regards the buds and fruits, but *E. Kesselli*
seems to differ mainly from *E. corrugata* in the broad
compressed peduncle and in the more turbinate fruits, the
valves of which are more slender, and the capsular disc
broader. The anthers are also broader than those of *E.
corrugata.*

2. With *E. Griffithsii,* Maiden, described in "Crit. Rev.,"
Part xvi., p. 208. The buds and fruits of *E. Griffithsii* are
in threes, like those of *E. corrugata* and *E. Kesselli,* but
the operculum is very short in *E. Griffithsii* and the fruits
are of a different shape and only faintly ribbed, while the
common peduncle is terete.

3. With *E. goniantha,* Turcz., dealt with in "Crit. Rev.,"
Part xvi., p. 200. From the imperfect material known of
E. goniantha it appears to differ from *E. Kesselli* in the
narrower leaves, different venation, and in the more nume-
rous flowers of the umbel. The anthers of both species are
very much alike, but those of *E. goniantha* seem to be
smaller and narrower.

13. E. KONDININENSIS Maiden and Blakely, n. sp.

Arbor mediocris, cortice 3-7 feet basin versus rugoso ramulis
lævibus; foliis junioribus leniter glaucis tenuibus petiolatis
undulatis ovatis vel oblongis obtusis 2-3.5 cm. longis, 1-1.5 cm.
latis, venis obscuris; foliis maturis dilute viridibus utroque
latere nitentibus crassiusculis angusto-lanceolatis acuminatis ad
falcato-lanceolatis, 6-11 cm. longis, 8.15 mm. latis, venis obscuris,
venis lateralibus e costa 30-40 orientibus; inflorescentia axillari,
umbellis in pedunculis brevibus subangularibus alabastra ad 7
breviter pedicellata ferentes; alabastris angustis cylindraceis,
operculo conoideo leniter costato calycis tubo vix longiore;

antheris paralleliter aperientibus; stigma clavata; fructibus campanulatis 5-7 mm. longis apice 5-6 mm. latis, valvis leniter exsertis.

A "Blackbutt," locally known under the name of "Stocking Tree" or "Black Yate." Attains a height of 40-60 feet, with erect or slightly spreading branches. Trunk to 30 feet in height and 30 inches in diameter. The bark reminds one very much of that of *E. Clelandi;* thick and flaky and black at the base to a height of 3-7 feet above the ground and persistent. This rough bark ends abruptly (hence the fanciful allusion to a stocking). Above, the bark is smooth, yellowish, shining, with a few blotches of purple-grey decorticating bark. Timber light to dark brown, dense and strong. Branchlets angular, assuming a reddish colour.

Juvenile leaves slightly glaucous, rather thin, petiolate, only two or three of the lowest pairs opposite, ovate to oblong, obtuse, slightly undulate, 2 to 3.5 cm. long, 1-1.5 cm. broad; venation obscure, intramarginal vein moderately close to the edge, secondary veins spreading, making an angle of about 40-50 degrees with the midrib.

Mature leaves light yellowish-green, glossy on both surfaces, moderately thick, narrow-lanceolate acuminate to falcate lanceolate, tapering at the base into a semi-terete peduncle, 1.5-2 cm. long, the leaf 6-11 cm. long, 8-15 mm. broad. Venation indistinct, intramarginal vein fairly close to the edge, lateral veins spreading at a rather high angle or at an angle of about 30-40 degrees with the midrib; midrib channelled above and slightly raised and obscurely channelled beneath.

Inflorescence axillary, the umbels on shortish, compressed and slightly angular peduncles, which support up to 7 very short pedicellate buds. Buds narrow, cylindrical, not seen fully ripe; calyx-tube about 4 mm. long, moderately smooth, slightly campanulate, tapering into a very

short, rather thick, angular pedicel. Operculum conoid, somewhat corrugated-striate in a dry state, scarcely longer than the calyx-tube. Anthers opening in parallel slits, with a large dorsal gland; filaments short, of a creamy-white colour. Stigma slightly thickened, more or less clavate. Floral disc represented by a thin membrane extending over the top of the ovary, and lining the calyx-tube.

Fruit campanulate, 5-7 mm. long, 5-6 mm. broad at the top, 3-4 celled, the short broad valves slightly protruding. Capsular disc rudimentary, represented by a white membrane over the valves, and a slight thickening of the inner wall of the calyx-tube and staminal ring.

Range.

It is confined to Western Australia, so far as we know at present. Collected at Kondinin, between Bendering and Gnarming, on loam flats forming open forest with *E. salmonophloia* and *E. Flocktoniae* (C. A. Gardner, Nos. 1843 and 1966).

Affinities.

1. With *E. melanoxylon,* Maiden. "Crit. Rev.," Part lvii., p. 351. In general appearance both trees appear to be much alike, both in habit, shape and colour of the leaves, nature of the bark and colour of the timber. Although the bark of *E. melanoxylon* is perhaps rather more deeply furrowed, and not discoloured with kino, and the timber is much darker, the timber of *E. Kondininensis* is a deep walnut-brown. In other characters both species differ from each other considerably.

2. With *E. dumosa,* A. Cunn., figured in "Crit. Rev.," Part iv., p. 97, and Part xxxviii., p. 220. In dealing with herbarium specimens one would naturally compare *E. dumosa* with *E. Kondininensis,* as the former is well known for its faintly striated or ribbed operculum, and its short, somewhat cylindrical fruits, but when other characters of

E. dumosa are taken into consideration, they are found to be markedly different from those of *E. Kondininensis*. The real affinity of the two species appears to be in the ribbed operculum, in the anther, and to some extent in the shape of the fruit. In habit *E. dumosa* is a dwarf Mallee with broadish, somewhat dull, bluish leaves, which retain their dullness and colour even when dry. *E. Kondininensis* is a tree up to 60 feet high.

3. With *E. Clelandi, Maiden.* This is also called "Black-butt" and is illustrated in "Crit. Rev.," Part xvi., p. 189. There is a slight resemblance between the buds and fruits of both species, but the buds of *E. Clelandi* are broader, with a more prominently ribbed operculum, besides being glaucous, and so also are the juvenile and adult leaves.

4. With *E. longicornis* F.v.M. See "Crit. Rev.," Part xv., p. 166, and Part xxxix., p. 272. The affinity with *E. longicornis* is mainly in the juvenile and adult leaves, which is so marked that young trees may be mistaken for either species. On the other hand, both species are very dissimilar in buds and fruits. *E. longicornis* is also a much larger tree.

14. E. MERRICKAE Maiden and Blakely, n. sp.

Mallee 4-10 feet altus; caulibus erectis vel patentibus 2-3 in. diametro dense ramulosis; cortice pallide cinereo, trunci junioris laevi, trunci autem vetusti lamelloso; foliis junioribus non visis, foliis maturis alternatis petiolatis angusto-lanceolatis crassis rigidis laevibus pallido-glaucis, supra subsutque nitentibus 4-6 cm. longis, 5-9 mm. latis, basi in petiolum breve et compressum angustatis; venis obscurissimis, venis lateralibus e costa 30-40° orientibus, vena peripherica margini confluente; inflorescentia axillari, pedunculo communi tereti alabastra cylindracea 8 parum obtusa ferente; calycis tubo companulato operculum fere hemisphericum longitudine plus duplo excedente, alabastro omni 10 mm. longo; pedicellis gracilibus 2-3 mm. longis; filamentis colore lactis floris imbutis, induobus ordinibus depositis; antheris versatilibus longitudinaliter aperientibus; fructibus crassis late campanulatis 7.9 mm. longis, 7 mm. latis, margine truncata, valvis brevibus et inclusis.

"Narrow-leaved Mallee." A Mallee, 4-10 feet high, of widely spreading habit. Stems erect or spreading, more or less virgate, densely branched, imparting to the plant an almost globular outline. Bark light ash-grey in colour, smooth when young, but becoming flaky when old, with tardily shedding plates of darker grey bark. Stems 2-3 inches in diameter. Leaves glaucous, narrow, buds shining with reddish opercula, and young reddish-green fruits which become mealy-white with age.

Juvenile leaves not available.

Mature leaves alternate, petiolate, narrow-lanceolate, somewhat thick and rigid, more or less acute, tapering into a rather short, compressed petiole, smooth, pale glaucous green and shining on both surfaces, 4-6 cm. long, 5-9 mm. broad. Venation obscure, the midrib more or less channelled on both sides of the leaf; the lateral veins spreading at an angle of 30 to 40 degrees to the midrib; intramarginal vein confluent with the nerve-like margin.

Inflorescence axillary, the common peduncle terete. about 5 mm. long, bearing 3 cylindrical, slightly obtuse buds. Calyx-tube somewhat campanulate, more than twice the length of the somewhat conical operculum, the entire bud about 10 mm. long; pedicels slender, 2-3 mm. long. Filaments cream-coloured, arranged in two rows around the staminal ring. Anthers (immature) versatile, oblong or nearly so, opening in long, parallel slits, the dorsal gland large, occupying nearly the whole of the back and usually projecting over the top of the cells in front. Floral disc forming a dark coloured lining over the top of the ovary and extending up the calyx-tube to the slightly raised staminal ring.

Fruit moderately thick, broadly campanulate, 4-celled, 7-9 mm. long, 7 mm. broad, somewhat shining, the rim or disc truncate, valves short and well enclosed. Capsular

disc forming a moderately sharp, slightly raised convex ring around the top of the fruit, or what was formerly the staminal ring, which still maintains its raised position.

This species is named in honour of Miss Mary Merrick, who, in her capacity as librarian and stenographer, Botanic Gardens, Sydney, has been of very great help to us in our Eucalyptus work.

Range.

So far it is known only from Western Australia. It has been found at Grasspatch, in sandy, loamy depressions around the salt lakes and saline flats, among other Mallees and small dense shrubs (C. A. Gardner, No. 1718, in field notes, No. 2218, on herbarium label, 23rd May, 1924).

Affinities.

1. With *E. Ebbanoensis,* Maiden, depicted in Part xlvi., Plate 189, "Crit. Rev." In the absence of complete material, that species appears to be its nearest affinity, in its Mallee-like habit, in the buds and fruits being in threes and to some extent in the shape of the immature anthers. The other botanical characters are, however, very different.

2. With *E. eudesmioides* F.v.M. This species is also more or less of a Mallee-like growth, and the inflorescence appears to be always in threes. The leaves, however, are opposite for a long period, and they are much shorter and broader than those of *E. Merrickae,* while the buds and fruits, although bearing a slight resemblance, are nevertheless quite distinct from those of *E. eudesmioides.*

15. E. OVULARIS Maiden and Blakely, n. sp.

Frutex parvus, Mallee similis 6-12 feet altus, caulibus gracilibus cortice stratis tenuibus secêdente; foliis junioribus non visis; foliis maturis alternatis, petiolatis, supra subtusque atroviridibus, nitentibus crassiusculis angusto-lanceolatis vel acuminatis leviter falcatis 6-10 cm. longis, 5-10 mm. latis; venis obscuris, venis lateralibus e costa 25-30° orientibus; vena

peripherica margini leniter incrassatæ approximata; inflorescentia axillari, pedunculo leniter compresso, sursum dilatato, umbellam 5-floribus pedicellatis ferente; alabastris urceolatiusculis, calycis tubo operculum obtusum plus dimidio excedente, 5 mm. longo, 3 mm. diametro basin versus; antheris oblongis truncatis longitudinaliter aperientibus; fructibus ovoideis 4-6 mm. longis, 4 mm. diametro, orificio contractis, plus minusve obscure costatis, margine angusta valvis bene inclusis.

A small, Mallee-like shrub, 6-12 feet high, with pinkish-grey, slender stems and flaky bark decorticating in thin flakes. Locally known as "Narrow-leaved Mallee" (C. A. Gardner).

Juvenile leaves not seen.

Mature leaves alternate, petiolate, dark green on both surfaces, shining and somewhat thick, narrow-lanceolate to somewhat acuminate, slightly falcate, 6-10 cm. long, 5-10 mm. broad. Venation obscure; lateral veins spreading at an angle of 25-35 degrees with the midrib; intramarginal vein very close to the somewhat thickened margin.

Inflorescence axillary, the common peduncle slightly compressed and expanded upwards, bearing an umbel of 5-8 pedicellate flowers. Buds somewhat urceolate, the calyx-tube slightly more than twice the length of the short, almost obtuse operculum, 5 mm. long, 3 mm. in diameter at the base. Filaments cream-coloured, inflected in the bud. Anthers oblong, or broader at the top, truncate, opening in parallel slits, the dorsal gland rather large and globose, inserted on the upper half of the anther. Floral disc represented by a membranous-like lining over the top of the ovary, and extending around the calyx-tube towards the base of the staminal ring.

Fruit ovoid, 4-6 mm. long, 4 mm. diameter, 3-celled, contracted at the orifice, the rim narrow, the surface more or less faintly ribbed, valves deeply sunk. Capsular disc forming a slightly thickened convex band around the orifice of the capsule, and slightly exceeding the calyx-rim.

Range.

It is confined to Western Australia, so far as we know at present. Found at a locality called "Salmon Gums," in open forest with *E. diptera* (C. A. Gardner, No. 2227, 24th May, 1924; the type).

Affinities.

1. With *E. dumosa* A. Cunn., dealt with in Parts iv. and xxxviii., "Crit. Rev." The buds of *E. ovularis* are very like some of the small-flowering forms of *E. dumosa*, and the immature anthers also resemble those of the latter species, but the fruits and other characters are very dissimilar.

2. With *E. Kondininensis* Maiden and Blakely, n. sp. The anthers of both species are somewhat alike, and the leaves are also narrow, but they are easily separated by other morphological characters.

3. With *E. oleosa* F.v.M. Some forms of *E. oleosa* are noted for their narrow leaves, and, in the absence of buds and fruits, could be easily confused with *E. ovularis*. As both species are of a somewhat similar habit, it is pardonable to make a mistake.

4. With *E. Dundasi* Maiden. See Part xxxiii., "Crit. Rev." Its affinity with *E. Dundasi* is mainly in the narrow, glossy leaves, and in the slightly urceolate buds, but the operculum is more rostrate in *E. Dundasi*, and the anthers are narrower.

5. With *E. cladocalyx* F.v.M., dealt with in Part xxxvi., p. 161, "Crit. Rev." The buds and fruits of *E. ovularis* are somewhat similar to some of the small forms of *E. cladocalyx*, but they are much smaller in the former, and the anthers are quite different.

16. E. STAERII Maiden.

Synonym: *E. marginata* Sm. var. *Staerii* Maiden, this Journ., xlvii., 230 (1913), and "Crit. Rev.," Part li., p. 13, Plate 210.

E. Staerii Maiden MSS., is described (except the Latin) in Kessell and Gardner's "Key to the Eucalypts of Western Australia," p. 110 (1924), with my concurrence, and it will be sufficient to transcribe it with some alterations and additions.

Arbor erecta 40-50ft. alta, trunco robusta ca 2ft. diametro, ramulis patentiusculis; cortice cinereo brunneo crasso longitudinaliter sulcato, parte exteriore in stratis latis secedente, ligno pallido-flavo; foliis junioribus tenuibus sessilibus ovatis pallido-viridibus, costa conspicua; foliis maturis crassis rigidis ovato-lanceolatis vel lanceolatis, 11 cm. longis, 4 cm. latis, vena peripherica a margine crassato remota; pedunculis axillaribus ca 2.5-3 cm, longis planis parte superiore dilatata umbellam 4-8 floram in pedicellis ca 5 mm. longis, ferentibus; calycis tubo obconico vel angusto-turbinato, operculo obconico, antheris reniformibus, fructibus globosis ca 2.5 c.m. diametro, margine prominente capsula leniter depressa, valvis obtusis inclusis.

"Albany Blackbutt." An erect tree of 40-50 feet with a stout trunk and rather spreading branches. Trunk to 30 feet and 24 inches diameter. Bark dark greyish-brown, thick and longitudinally fissured, the fissures more or less whitened or yellowish-grey, the outer bark shedding in broad flakes not as stringy as those of the Jarrah (*marginata*), but not friable as the Blackbutt (*patens*) bark. It is intermediate between the two in character and appearance. Timber pale, yellowish. Branches crooked. The inner flakes of bark reddish.

Juvenile leaves not seen in quite the youngest state, ovate, thin, sessile, pale green, with conspicuous midrib and purple-red nerves, the secondary veins spreading and irregular, the intramarginal vein distant from the edge.

Obtuse and roughly 2 inches (5 cm.) long by 1¼ inches
(3 cm.) wide. Mature leaves ovate-lanceolate to lanceolate,
thick and rigid, on very angular branchlets and with flat-
tened, twisted petioles, acuminate, pale green with a thick
yellowish midrib and fine roughly parallel spreading veins;
the intramarginal one at a distance from the thickened
margin. Peduncles axillary, about 1 inch (2.5 cm.) long,
stout and flattened, widened near the top, supporting an
umbel of 4-8 rather large flowers on fairly long angular
pedicels. Calyx-tube obconical or narrowly turbinate,
tapering into the pedicel. Operculum conical, slightly
spreading at the base and forming a prominent angle with
the calyx-tube. Filaments whitish; anthers kidney-shaped,
opening in upwardly confluent slits. Fruits globose, about
1 inch (2.5 cm.) in diameter, with a prominent rim and
slightly sunk capsule with obtuse included valves.

The name commemorates John Staer, seed-collector, from
whom I originally received specimens.

Range.

Confined to South Western Australia (at no great dis-
tance from King George's Sound), so far as we know at
present. Occurs on sandy, usually sub-swampy flats near
Albany, extending over the sandy places to Denmark and
near the Kent River; flowers yellowish-white, flowering in
November.

Affinities.

1. With *E. marginata* Sm. Compare the figure of *E.
Staerii* (as *E. marginata* var. *Staerii*) on Plate 210, with
that of *E. marginata* on Plate 230 ("Crit. Rev."). The
leaves are much the same, but the fruits are different, in
the former being larger, globose, and when ripe, with exsert
valves and a wider rim, those of the latter being pyriform,
and with slenderer peduncles and pedicels. Mr. Gardner's
opercula of *E. Staerii* are conical, while those of *E. mar-*

ginata are very much more elongated. The differences in the two barks have already been described, while the two species are sharply separated by the pale-coloured wood of *E. Staerii* and the well known deep red, heavy wood of the latter.

2. With *E. Todtiana* F.v.M. See Part xx. and Plate 88, "Crit. Rev." The timbers of the two species are pale-coloured, and but of little economic value; the fruits are of about the same size and shape, but those of *E. Todtiana* have smaller apertures and thinner rims. The latter species is scarcely found south of Perth, while the home of *E. Staerii* is the King George's Sound district. The anthers of both species are, however, quite different. The affinities of the two species require to be further worked out.

We desire to emphasise our indebtedness to Mr. C. A. Gardner, late of the Forest Department of Western Australia, for valuable notes and specimens of most of the Western species, and take the opportunity of thanking Dr. G. P. Darnell-Smith, Director of the Botanic Gardens, Sydney, for many courtesies in connection with the preparation of this paper.

THE KOSCIUSKO PLATEAU,

A Topographic Reconnaissance

by

Associate-Professor Griffith Taylor, D.Sc., B.E.,

Assistant-Professor W. R. Browne, D.Sc., and

F. Jardine, B.Sc.

(With one text figure and plates I -III)

(Read before the Royal Society of New South Wales, Sept. 2, 1925.)

Introduction.—Early in 1922 the first-named author was asked by Sir Edgeworth David to carry out a rapid topographic survey of the Kosciusko Plateau with a view to preparing a model of this very interesting locality. Professor Browne and Mr. F. Jardine were associated with the work throughout, and after the first few days each investigator worked at a separate region so as to cover the whole ground in the fortnight allotted to the field survey. Considerable help as regards transport and accommodation was given by the Chief Secretary's Department (including the Tourist Bureau), and by the Department of Education. The writers express their gratitude accordingly.

Method of Work.—In the time available it was not possible to prepare an accurate contour map of a mountainous region of 20 miles long and 6 miles wide. Two or three factors, however, made it possible to produce a useful map in the time. In the first place a well-built motor road traverses the plateau, marked with milestones and heights—so that we could refer to these quite frequently. Again, the upper western portion of the plateau (above 6000 feet) is mainly open country consisting of

heather, grass or bare slopes. Here levels and directions could be rapidly obtained. The lower portion to the east is generally thickly wooded with a eucalypt forest, which makes it much harder to obtain levels. As, however, this lower portion was much less interesting from a physiographic point of view, we did not attempt to map it in any great detail.

The first day or two was spent in the vicinity of Digger's Creek, but thereafter we made Betts' Camp our headquarters. We spent one night in the broken-down hut on the side of Kosciusko. The last few days our tracks radiated from the Hotel or from "The Creel" at the entrance to the Plateau. The measurements were made by prismatic compass, aneroid and Abney level. The levels were checked by reference to some known height, morning and evening, but we did not attempt to correct for daily barometric change by comparison with a barograph. Hence our levels are described on the map as "formlines" and not as "contours." A great number of photographs (whose directions were recorded) and panoramic sketches were used in completing the topography. As stated on the map, we did not attempt to survey the regions on the left bank of the Snowy below Blue Lake, or on the right bank of the Crackenback River. The region just south of the elbow of the Snowy River is rather inaccessible, and hence has not been adequately mapped.

Since this paper is not primarily concerned with the geological or physiographic features, we do not propose to give a bibliography of former work on the Plateau. The chief two papers of comparatively recent date are by Professor Sir Edgeworth David (Roy. Soc. N.S.W., 1908) and by David, Pittman and Helms (Roy. Soc. N.S.W., 1901).* Further literature is mentioned therein.

* A block diagram and some notes on the glacial features appear in "The Geographical Laboratory" by G. and D. Taylor, Sydney, 1925.

In 1909 a map of the Plateau showing some topographic features by means of rough hachures was prepared by the late Government Architect (Mr. W. L. Vernon), and published by the Tourist Bureau. Although it was difficult to estimate heights from this map, we found it of considerable assistance in our own survey. The parish-maps published by the Lands Department were also called into service, though they show little but the plan of the creeks and rivers.

The writers desire to express their hearty thanks to the head of the Commonwealth Department of Lands and Surveys, and to his officers for the care with which they have converted our original field contour-map into the finished map published herewith.

Salient Features.—Details of the topography and glaciology will be discussed in a later publication, only the salient features being noted here. The Plateau as surveyed consists of a rectangular area (some 20 miles by 6) whose long axis runs approximately northeast and southwest (see Fig. 1). It is well-defined on all sides except the west,.
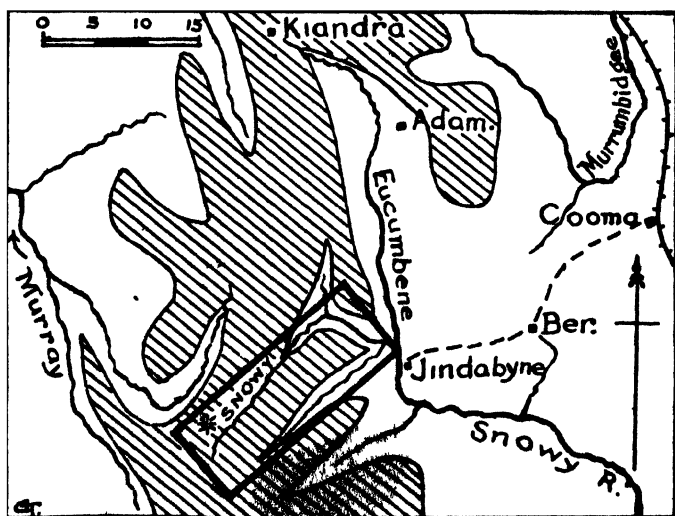

Fig. 1.—The region around Kosciusko The heavy black rectangle shows the area mapped and modelled. The ruled regions are approximately over 4000 feet Mount Kosciusko is shown by the star.

where it merges into the main divide of the State. Along
the northwest and northeast it is bounded by the deep
Snowy River Valley; along the southeast by the linear
Crackenback-Thredbo gorge, and on the west and south-
west the Plateau slopes steeply into the valley of the
Murray and its tributaries. From Kosciusko in the ex-
treme west of the survey, the divide runs north-northeast
through Mt. Twynam towards Kiandra. We have not
mapped the divide beyond Mt. Twynam, though it was
very apparent as a flat upland of some 6000 feet elevation
all along the northwest side of the Upper Snowy Valley.

The rectangular block with which we are concerned
rises fairly gradually from east to west. At the junction
of the Thredbo River and the Snowy River (near "The
Creel"), it is 3000 feet above the sea. Mount Kosciusko
at the other extreme is about 7328 feet high. Only a few
isolated patches along the divide rise above 7000 feet.
We have shown Kosciusko, Townsend, Twynam and Ram's
Head as over 7000, while two smaller portions may just
reach that elevation.

A horseshoe-shaped area surrounding the Snowy head-
waters exceeds 6500 feet. The western "limb" is about
9 miles long and the eastern about 6 miles. The
"Perisher" is the only notable "outlier" of this height,
but two other mountains (P_2 and P_5) on the map near
Perisher just about reach 6500 also. There is a very
marked drop in the Plateau east of the Perisher Creek,
for practically all the high land (over 6000 feet) lies to
the west.

Only a few summits (e.g., Mt. Sunrise, Pretty Point,
and T_3) approach this height to the east of that creek.
The 5000 feet contour bounds the Plateau uplands around
the lower Snowy River, which flows through a gorge
which is largely below that level.

The drainage is arranged according to a very interesting plan. The main stream of the district is really the broad Eucumbene valley in the extreme east. This is longer and "older" than the Snowy Valley. The latter has cut back as a gorge into the uplifted plateau—probably along fault planes—as far back as Charlotte's Pass. Above this the valley is fairly wide and approaches maturity. Further west, the headwaters, above the road-ford, flow as meanders through a flat senile valley. The Crackenback-Thredbo Valley is a profound gorge for most of its extent. We did not descend to the river, except near The Creel in the east. Besides these two parallel gorges of the Snowy and Crackenback, there is a third more or less continuous valley running between them. Since this is occupied by the main road, we may refer to it as the "Road Valley." It consists of a series of shallow basins linked by cols or gaps. Thus from east to west (ascending up the road) we cross Rennix Gap, the Hotel "Basin," Daner's Gap, Piper's Basin, Piper's Gap, Perisher Basin, Perisher Gap, Spencer's Basin and Charlotte Pass. Each of these Basins drains to the north by a creek leading into the Snowy River. This "Road Valley" is about 1000 feet above the two parallel river valleys. Its topography is probably in part due to bygone glacial erosion.

As regards the map itself we have added several new glacial features. The most notable are the large ancient moraines which we have named after Sir Edgeworth David and Sir David Masson. A very perfect crescentic moraine on the east side of the Etheridge Range is named after Dr. H. I. Jensen, who carried out lengthy observations in the old Mount Kosciusko observatory. These with similar examples will be described elsewhere.

We were able to identify a number of new cirques, notably south-east of Charlotte's Pass, near Club Lake and

DEPT OF GEOGRAPHY
1922
SYDNEY UNIVERSITY
A RECONNAISSANCE OF
THE KOSCIUSKO PLATEAU
APPROXIMATE CONTOURS BY
TAYLOR BROWNE & JARDINE

RIVER

CRACKENBACK

among the Perisher group of mountains. None of these
is so typical as the Blue Lake cirque—or as those of
Cradle Mountain and Mount Field in Tasmania. In
order to facilitate reference to unnamed features we have
adopted the usual plan of naming them with a group-
letter and a number. These can be replaced by appropriate
names in the future. Two plates are inserted which illus-
trate the large model prepared from our survey map by
the second year students in the Department of Geography,
1922. The model is 4½ feet long; and the vertical scale
is twice the horizontal scale. As a result the model has
almost exactly the appearance of the natural topography;
whereas a true scale model would appear too flat.

DESCRIPTION OF PLATES.

Plate I. — Map of Kosciusko Plateau (20 miles by 6 miles),
where the elevations are represented by form-lines or ap-
proximate contours.

Plate II.— Photograph of a Model of the Kosciusko Plateau,
viewed from above. The original model is 4½ feet long.

Plate III.—Photograph of the model, looking due west towards
Kosciusko (shown as the highest knob in the distance) from
the junction of the Thredbo and the Snowy Rivers at the
extreme east.

THE ESSENTIAL OIL OF *ERIOSTEMON*
MYOPOROIDES (DE CANDOLLE).

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The botany of this Rutaceous plant is fully described in "Flora Australiensis", Volume 1, page 333. It is a stout, usually tall, glabrous shrub, with narrow greyish-green leaves and small white flowers, and occurs along the coast to tableland district of New South Wales, Victoria and Queensland. It is very abundant at Emu Plains, situated at the foot of the Blue Mountains of this State, growing luxuriantly on the slopes adjacent to the water courses, where the major portion of the material examined was collected. On crushing the leaves between the fingers a characteristic pleasant odour is evolved in which both pinene and ocimene can be detected.

The oils from the three consignments were very mobile, of a bright yellow colour, with a most pronounced fluorescence indicative of the methyl ester of anthranilic acid, and of pleasant terpenic odour. The yield of oil from two widely different localities, 200 miles apart, was practically constant, 0.75%. The principal constituents which have so far been determined proved to be *d-a*-pinene (75-85%), ocimene, ledum camphor (Denman sample), a sesquiterpene, methyl anthranilate, a paraffin of M.Pt. 64-65°, with traces of a phenolic body.

Experimental.

1111-lbs. of leaves and terminal branchlets collected at Emu Plains and Denman, both of N.S.W., yielded on distillation with steam, crude oils possessing the chemical and physical characters, as shown in table:—

Date.	Locality.	Weight of leaves.	Percentage yield of oil.	Specific Gravity. $\frac{15}{15}$	Optical Rotation.
5/8/1924	Denman, N.S.W.	78-lbs.	0.77%	0.8789	+ 29.2°
13/10/1924	Emu Plains, N.S.W.	530-lbs.	0.76%	0.8580	+ 36.75°
3/3/1925	Ditto	503-lbs.	0.71%	0.8584	+ 36.75°

Refractive Index 20°.	Solubility in 80% alcohol (by weight).	Sap. No. hot, 1½-hours.	Sap. No. hot, 1½-hours after acetylation.
1.4740	insoluble in 12 vols.	6.13	24.69
1.4690	do.	6.38	14.59
1.4687	do.	4.61	16.18

The crude oils were subjected to fractional distillation under reduced pressure, and the terpene fractions thus separated were again repeatedly redistilled over metallic sodium, both at 10-20 mm. and 769-770 mm., when the following fractions were finally obtained:—

1st lot (Denman)—

Boiling point.		Volume percentage.	Specific Gravity	Optical Rotation.	Refractive Index, 20°.
155-157°	(753mm.)	43%	0.8603	+41.62°	1.4660
157-159°	(753mm.)	19%	0.8580	+39.80°	1.4671
60-74°	(20mm.)	7%	0.8417	+24.60°	1.4735

2nd lot (Emu Plains)—

Boiling point.		Volume percentage.	Specific Gravity	Optical Rotation.	Refractive Index, 20°.
155-157°	(769mm.)	87%	0.8608	+42.25°	1.4660
157-161°	(769mm.)		0.8583	+39.5°	1.4674
68-70°	(20mm.)	4%	0.8439	+26.8°	1.4715
70-78°	(20mm.)	4%	0.8314	+15.2°	1.4760

3rd lot (Emu Plains)—

Boiling point.		Volume percentage.	Specific Gravity	Optical Rotation.	Refractive Index, 20°.
155-157°	(770mm.)	80%	0.8593	+40.7°	1.4668
157-158°	do.	7%	0.8566	+37.8°	1.4676
158-165°	do.	4%	0.8523	+32.7°	1.4743
165-175°	do.	2%	0.8467	+26.75°	1.4816
175-185°	do.	1%	0.8374	+15.1°	1.5027

Determination of d-a-pinene.—Whilst the chemical and physical constants of the various fractions of boiling point 155-157°, as shown in table, pointed to the principal terpene being *d-a*-pinene, the lower specific gravities, high refractive indices and the readiness with which the various fractions resinified, was very pronounced evidence of admixture with an olefinic terpene which was impossible of complete separation by fractional distillation. Accordingly, specimens of both Denman and Emu Plains fractions of boiling point 155-157° were oxidised with potassium permanganate (see this Journal, Vol. LVI, page 195), and the pinonic acid was separated as described therein. It distilled in both cases at 176-182° at 5 mm. and solidified immediately on condensation. The crystals were separated and purified from petroleum ether (B. Pt. 50-60°), when they melted at 68-69° and 69-70° respectively. The semicarbazones of each were prepared, the melting point being 207°. The specific rotations were as follows:—

Denman Sample—

0.6174 gram in 10 c.c. chloroform gave a reading of +5.5°.

$$[\alpha]_D^{20°} + 89.08°$$

Emu Plains Sample—

1.0940 gram in 10 c.c. chloroform gave a reading of +9.9°.

$$[\alpha]_D^{20°} + 90.7°$$

The hydrochloride of the Denman sample was prepared in the usual way, when on recrystallisation from absolute ethyl alcohol it melted at 130-131°; 0.5254 gram in 10 c.c. ethyl alcohol gave a reading of +1.75° at 16°.

$$[\alpha]_D^{16°} + 33.34°$$

Determination of ocimene.—2400 c.c. of the crude oil (Emu Plains lot) were repeatedly distilled under reduced pressure, when finally 27 c.c. of a very mobile liquid was obtained, which on distillation over sodium boiled at 75-78° at 20 mm. It possessed the following constants:—

Specific Gravity, $\frac{14°}{15°}$ .. 0.822
Optical Rotation .. .. +9.4°
Refractive Index, 16° .. 1.4800

Although still contaminated with d-a-pinene, the sample possessed the characteristic odour and physical characters of ocimene. On reduction with sodium and alcohol, crude dihydromyrcene was obtained of boiling point, 68° at 20 mm., specific gravity, $\frac{15°}{15°}$, 0.795, and refractive index, 20°, 1.4520. The characteristic bromide was prepared and isolated, when on re-crystallisation from hot absolute alcohol it melted sharply at 88-89°. The identity of ocimene was thus confirmed. It will be observed on reference to the table that fraction, 175-185°, which had been distilled over metallic sodium at 770 mm., had a refractive index of 1.5027 due to the conversion of ocimene to allo-ocimene.

Determination of anthranilic acid methyl ester.—The small residues left after removal of the terpenes were united, dissolved in ether, shaken with dilute sulphuric acid, and the dissolved ester liberated by means of caustic soda solution and taken up with ether. After removal of the solvent a small quantity, about a half c.c., of a highly fluorescent liquid was left, which was treated with picric acid dissolved in the smallest possible volume of alcohol. The very small quantity of picrate obtained was re-crystallised from ethyl alcohol, when it melted at 103-104°.

Determination of ledum camphor.—200 c.c. crude oil, ex Denman consignment, on distillation yielded 152 c.c. distilling below 74° at 20 mm. The residue on pouring from the flask solidified immediately. It was cooled for some days at 0° and transferred to a Buchner funnel, whereby 13 grams of a white crystalline solid were obtained. (The filtrate, on cooling for a number of months

in the ice-chest, yielded a further 1.5 grams of prismatic
needles.)   It was readily soluble in all the usual organic
solvents, but was best re-crystallised from absolute ethyl
alcohol, when it melted sharply at 104°.   It was a beauti-
fully crystalline body, separating from solvents and
subliming in long prismatic needles: 1.0366 grams dis-
solved in 10 c.c. chloroform at 20° gave a reading of +2.9°,
$[a]_D^{20°}$ +27.97°

The following results were obtained on combustion:—
(1) 0.1010 gram gave 0.2998 gram CO_2 and 0.1050 gram
H_2O.   C = 80.95%.   H = 11.55%.
(2) 0.1008 gram gave 0.2992 gram CO_2 and 0.1061 gram
H_2O.   C = 80.95%.   H = 11.69%.
$C_{15}H_{26}O$ requires   C = 81.08%,   H = 11.71%.

A molecular weight determination by the boiling point
method (0.8908 gram in 30 c.c. acetone elevated the boiling
point 0.3°) gave a result of 218: $C_{15}H_{26}O$ requires 222.

The above experimental work proves the body to be a
sesquiterpene alcohol, and to be identical with ledum
camphor isolated from the oil of Labrador Tea (Ledum
palustre, N.O. Ericacae), as per Gildermeister & Hoff-
man's "Volatile Oils" (1922), Volume III, pp. 383-384.
This alcohol has not previously been observed in an
Australian essential oil, and is the second recorded in-
stance of its occurrence.   Owing to the comparatively
small quantity of the sesquiterpene alcohol available, only
a few grams could be spared for conversion to the corres-
ponding sesquiterpene.

On treating 3 grams with 100% formic acid at 20°,
water was immediately split off with separation of a sesqui-
terpene.   It gave an olive green colouration with bromine
in acetic acid solution, and a bright emerald green colour
with sulphuric acid in acetic anhydride solution.

Determination of sesquiterpene.—After allowing the filtrate from the ledum camphor to stand for several months in an ice-chest, and freeing from a further 1-2 grams of solid, the liquid (about 10 c.c.) was separated, and distilled over metallic sodium. It boiled at 130-135° at 10 mm., had a specific gravity, $\frac{15}{4}°$, 0.9636, optical rotation, —39°, and refractive index, 16°, 1.4982. It gave all the usual colour reactions for sesquiterpenes, but failed to yield any of the usual crystalline derivatives.

Determination of a paraffin.—The high boiling residues from the sesquiterpenes, on treatment with acetic acid and ethyl alcohol, yielded a small quantity of a paraffin. On re-crystallisation from hot ethyl alcohol it melted at 64-65°.

I have to express my thanks to Mr. F. R. Morrison, A. S. T. C., A. A. C. I., Assistant Economic Chemist, for his usual assistance in this investigation.

THE HUMAN SEX-RATIO AND THE REDUCTION
OF MASCULINITY THROUGH LARGE FAMILIES.

By Sir George Knibbs,

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Hon. M.S.S.Hung.; etc.

(Read before the Royal Society of New South Wales, Sept. 2, 1925.)

Synopsis.—1, General. 2, Masculinity in general. 3, Significance of high masculinity of still-births. 4, Effect of multiple-births on masculinity. 5, Masculinity and size of family in Australia. 6, Constitution of families referred to in "Who's Who." 7, Probabilities of the constitution of groups of families of children. 8, The decrease in the numbers of cases. 9, Parkes' Peerage results. 10, Difference of masculinity of living and deceased issue. 11, Conclusions.

1. *General.*—The phenomena of the sex-ratios of various forms of life are of the first order of importance, and among them, those which throw light upon the make-up of human populations are of special interest.

Up to age 50 the number of males usually exceeds the number of females in the case of both eastern and western populations. From that age onward the males are in defect in the west, but in the east are in defect only from age 60 onward (see the table hereunder) : females are in excess.

About the beginning of the present century, the number of males per 1000 females, in the aggregate of ten western countries, viz., Canada, England and Wales, Germany, Ireland, Italy, Newfoundland, Norway, Scotland, Sweden,

the United States and Australia (see line "W" below), and of the Cape of Good Hope, Ceylon and India (see line "E" below) were as follow:—

Age		0	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Ratio	W	1024	1016	1014	1015	992	979	991	1005	1021	1020	1012
„	E	1008	966	1047	1212	1073	919	1022	1037	1135	1035	1131
Age		50-54	55-9	60-4	65-9	70-4	75-9	80-4	85-9	90-4	95-9	0-100
Ratio	W	988	962	934	927	906	895	847	784	674	588	996
„	E	1005	1095	870	882	873	885	873	905	880	880	1039

2. *Masculinity in general.*—"Masculinity" may be expressed in the way indicated, or, better still, by the difference between males and females divided by their sum; that is $(M—F)/(M+F)$. Per 10,000 nuptial births and per 10,000 ex-nuptial births in Australia from 1919 to 1923 the masculinities were respectively as follow:—

Australian Masculinities at Birth, 1919-1923.

Year ..	1919	1920	1921	1922	1923	Average	"Deviation"
Nuptial	292	301	285	267	259	281	15.6
Ex-Nuptial	403	560	296	337	172	354	127.8

The irregularity of the ex-nuptial cases is very striking: the "mean square deviation" is as shown in the final column.

The ratio of males to females for still-births divided by that ratio for live-births gives quotients of from about 1.16 to about 1.36, and for Australia the ratio of males to females for nuptial first births was about 1.00246 more than the mean for other births (1908 to 1913). For more recent periods it was found to be as shown in the following table, which gives the numbers of males per 1000 females, for most countries of Europe,* viz., for Switzerland, France, Denmark, Austria, Portugal, Sweden, Netherlands, Belgium, Norway, Finland, Hungary, Bulgaria, Iceland, Spain and Greece:—

COUNTRY.

Swiz.	Fr.	Den.	Aust.	Port.	Swed.	Neth.	Belg.	Nor.	Fin.	Hung	Bulg.	Ice.	Spn.	Gr.

LIVE BIRTHS.

| 1051 | 1053 | 1055 | 1056 | 1057 | 1058 | 1059 | 1059 | 1060 | 1061 | 1070 | 1072 | 1075 | 1098 | 1163 |

STILL BIRTHS.

| 1291 | 1366 | 1242 | 1299 | 1293 | 1259 | 1248 | 1311 | 1267 | 1306 | 1285 | 1390 | 1112 | 1436 | 1511 |

* See G. H. Knibbs, Journ. Roy. Soc., N.S. Wales, 1925, p. 128.

The means of the first seven countries, of the upper and lower figures, are 1048.4 and 1285.4 respectively, and of the last eight countries are 1082.2 and 1321.0 respectively. These make the masculinity for still births that for live births multiplied by 1.2262 in the former case and 1.2206 in the latter; or say on the average by about 1.2234. Or dividing the total into three groups of five we get the following results:—

				Means.
Live Births, Averages of five countries	1.0544	1.0594	1.0956	1.0698
Still births, Averages of five countries	1.2982	1.2782	1.3368	1.3044
Ratios, Still to Live Births	1.2312	1.2065	1.2202	1.2198

One may say, therefore, that for western peoples the ratio of males to females for still births is about 1.305; that for live births is about 1.070, and the ratio between the two is 1.220. Other examples given elsewhere by me* show that the ratio ranges between 1.157 and 1.360, and average about 1.240, and Western Australia, 1914 to 1924, gave 1.0455 for live-births, 1.2892 for still-births, the ratio being 1.2331 between them.

That this sex-ratio, males to females, is invariably greater for still than for live-births indicates that male lives are in greater jeopardy prior to birth than are female lives.

3. *Significance of high masculinity of still-births.*—The significance of the difference of the sex-ratio for still and live-births may be seen from the consideration of the relative numbers in the two cases. Thus, symbolically,

Still births=m+f.   sex-ratio m/f.

Live   „   =M+F;   „   M/f.

Total   „   =M+m+F+f;   „   (M+m)/(F+f).

Thus, though the sex-ratios may differ greatly in the two cases, the ratio over all is but slightly affected. For example, in Western Australia, from 1908 to 1913, the sex-

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* See Mathematical Theory of Population, Appendix A, Australian Census 1911, p. 188.

ratio (M/F) for all births was 1.0534, while for all live-births it was 1.0476, the total still-births being M.853, F.678, and total live-births M.25057, F.23919. The sex-ratio for the still-births was no less than 1.258.

The ratio of still to live-births in Western Australia for males was 0.03404, and for females 0.02835, for both combined 0.03129. Thus, apparently, though effective insemination may be more frequent for males, the risk of death before or at birth is appreciably greater than for females.

4. *Effect of multiple-births on masculinity.*—I have shown elsewhere that ratio of males to females is reduced by multiple births.* In the late German Empire, for example, during the period 1906-13, for such births this ratio, per 10,000 females, was almost exactly given by the formula

$$M/F = 10560 - 103\, N^3,$$

where N is the *excess* of births over 1. Per 1000 females the formula gives

Ratio 1000 M/F.	Total births at confinement	1	2	3	4
,,	By above formula	1056	1046	974	778
,,	Actually	1056	1037	974	778
Ratio (M—F)/(M+F), or "masculinity"		272	224	—134	—1248
By formula hereunder		272	224	—150	—1240

This last result is closely represented by the formula

$$(M - F)/(M + F) = 272 - 47.5\, N^{3.15},$$

N being again one less than the number of multiple births, and the ratio the "masculinity."

Inasmuch as everywhere the numbers of multiple births are relatively very small (for example, in Australia per ten million confinements there are only 98,020 twins, 829 triplets, 15 quadruplets, and perhaps 2 quintuplets, or, roughly, 1 in a hundred confinements for twins, and about 1 in 10,000 for triplets), it is evident that these can affect the general masculinity but very slightly. And although

* G. H. Knibbs, Journ. Roy. Soc., N.S. Wales, 1925, p. 128.

the linear increase of the frequency of twins, with the age x of the mothers increases in the ratio $1 + 0.00066$ $(x\text{-}12)$ very approximately,[*] and thus is most effective at the ages associated with large families, it has but a very small effect. For this reason the variation of masculinity with size of family, which will be shown hereinafter to occur, must be regarded as a fundamental fact in the phenomena of human reproduction, just as much so as the production of fertile male ova exceeds in number that of fertile female ova, and not regarded merely as a consequence of multiple births.

5. *Masculinity and size of family in Australia.*—The families and issues quoted hereunder are compiled from data courteously supplied by Mr. C. H. Wickens, F.I.A., etc., Commonwealth Statistician of Australia, and furnish the means of comparing with families of different sizes, the masculinity of the issue. They are based on the records of the total issue of married males and married females who died during the three years, 1922 to 1924, and are as follow :—

Masculinity of Total Issue, Australia 1922 to 1924,
per 10,000 children.

Issue	Families	M. Issue.	F.	Masculinity	Calc.
1	8,369	4,374	3,995	453	427
2	9,078	9,428	8 728	386	391
3	9,093	14,153	13,126	376	359
4	8,800	18,263	16,937	377	330
5	8,091	20,765	19,690	266	305
1 to 3	26,540	27,955	25,849	391	391 abt.
4 and 5	16,891	39,028	36,627	317	317 abt.
6 and 7	14,441	47,670	45,370	247	276 abt.
8 and 9	11,486	49,751	47,371	245	249 abt.
10 to 12	9,612	51,698	49 822	235	237 abt.
13 and over	2,405 .	17,308	16 423	260	—
10 and over	12,017	69,006	65,745	242	—
Totals ..	81,375	233,410	220,962	274	over all

The masculinity given in the table is 10,000 times the ratio of the difference of the males and females divided by

[*] See G. H. Knibbs, Roy. Soc., N.S. Wales, 1925, p. 128.

their sum; *i.e.*, 10,000 (M—F)/(M+F). It shows initially a marked diminution as the size of the family increases, but for families of 13 children and over it seems again to increase. The numbers on which these last results depend are, however, rather small. Families of 1, 2 and 3 issue have also been combined, and also those of 4 and 5 issue, of 6 and 7, 8 and 9, 10 to 12, and 13 and over, with the results shown. A second degree curve, adopted to represent the results on the whole, is approximately :—

$$\text{Masculinity} = 467.6 - 42.15n + 1.93n^2$$

where n is the number of children in the family. It does not, however, fit very well; in fact, no regular curve will. This function for 0 is 467.60; the first difference is — 40.22 and the constant difference + 3.86. These constants give the following *calculated* values :—

Family	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Masc. .	467.6	427	391	359	330	305	284	267	254	245	239	237	240	246

The *actual* results do not show this steady diminution but indicate that there are two decreases of masculinity, viz., for families of 1 to 3 children; then 3 and 4 are the same; when a sudden decrease to families of 5 occurs. The results then oscillate, and actually, for families of 6 to 12, are as follow :—

No. in Family	5	6	7	8	9	10	11	12
Masc. per 10,000 ..	266	231	366	231	260	225	231	259

6. *Constitution of families referred to in "Who's Who."* —The following data are obtained from the issue of persons as reported in "Who's Who"; about the first half of the cases quoted. They are classified according to the total number in the families and their constitution as regards their differing numbers of males and females. The numbers are the number of children and the number of families with that number are shown in brackets, thus, (1280). The probability of their occurrence is shown, and the masculinities per 10,000 are given.

Families of Constitution — 1 (1280), 2 (1528), 3 (1151)

	1 (1280) M.	F.	2 (1528) 2M.	MF.	2F.	3 (1151) 3M.	2MF.	M2F.	3F.
Numbers	672	608	347	818	362	121	432	460	119
Probability	640	640	382	768	382	144	451	481	144
Masculinity	+500		—98			6—			

Families of Constitution — 4 (690), 5 (289)

	4 (690) 4M.	3MF.	2M2F.	M3F.	4F.	5 (289) 5M.	4MF.	3M2F.	2M3F.	M4F.	5F.
Numbers	45	180	262	165	36	10	61	96	64	43	15
Probability	43	172	260	172	43	9	45	91	91	45	9
Masculinity	+210					+422.					

Families of Constitution — 6 (203), 7 (98)

	6 (203) 6M.	5MF.	4M2F.	3M3F.	2M4F.	M5F.	6F.	7 (98) 7M.	6MF.	5M2F.	4M3F.	3M4F.	2M5F.	M6F.	7F.
Numbers	0	19	48	54	56	22	4	1	5	15	26	23	21	6	1
Probability	3	19	48	63	48	19	3	1	5	16	27	27	16	5	1
Masculinity	—427							—292							

Families of Constitution — 8 (45), 9 (27)

	8 (45) 8M.	7MF.	6M2F.	5M3F.	4M4F.	2M5F.	2M6F.	M7F.	8F.	9 (27) 8M.	7M2F.	6M3F.	5M4F.	4M5F.	3M6F.	2M7F.
Numbers	1	0	5	13	11	6	6	3	0	1	3	5	6	6	4	2
Masculinity	Zero.									+661						

Families of Constitution — 10 (14), 11 (.)

	10 (14) 8M2F.	7M3F.	6M4F.	5M5F.	4M6F.	3M7F.	2M8F.	11 (.) 4M7F.
Numbers	1	1	3	4	2	2	1	1
Masculinity	—143							—2737

Families of Constitution — 12 (1), 13 (5), 15 (1)

	12 (1) 2M10F.	13 (5) 8M5F.	7M6F.	5M8F.	15 (1) 8M7F.
Numbers	1	3	1	1	1
Masculinity	—6667		+1077		+667

7. *Probabilities of the constitution of groups of families of children.*—If the chances of a male birth and a female birth were exactly equal, then, evidently, where the issue is n in number, the relative numbers of different cases in such an issue will be as the integers in $(1 + 1)^n$; that is, they will agree with those of "Pascal's triangle." Or, to state it in another way, the possible permutations are the relative numbers in question and are $n!/(a!\,b!)$, in which $a + b = n$, they being the various possible numbers of males and females in the issue. They are, for groups of families of from one to seven children, respectively :—

1.1;   1.2.1;   1.3.3.1;   1.4.6.4.1;   1.5.10.10.5.1;   1.6.15.20.15.6.1;   1.7.21.35.35.21.7.1.

To find the distribution to be expected on the assumption adopted, let the cases be divided in the proportion of that series of numbers, casting them, of course, to whole num-

bers. Thus, for issue of 7, for which there are 98 cases, $2^7 = 128$, hence the expected numbers are $98/128$ ($= (7/8)^2$ or 0.7656) multiplied into each of the figures 1, 7, 21, 35, 35, 21, 7, 1. This gives the expected cases. They are about 0.77, 5.36, 16.07, 26.80, etc. Cast to the nearest units these are 1, 5, 16, 27, etc., and very nearly agree with the distribution actually occurring (see table above). The expectations, as far as families of 7 children are concerned, are shown on the last lines but one in the above results. The actual masculinity, over all, is shown in the final line, but often depends upon very small numbers. It will be seen that in cases of families of 2 to 10 the masculinity is always less than in families of 1 child. The numbers of the families of various sizes, however, are not large enough to allow great weight to be attached to the result, and for the larger families the numbers are very small. The number of the families are shown in brackets and the males and females in each are as follow, the males being the first of each pair of numbers:—

Family	1 (1280)	2 (1528)	3 (1151)	4 (690)	5 (289)	6 (203)
Males and Females ..	672, 608	1512, 1542	1725, 1728	1409, 1351	753, 692	583, 685
Family	7 (98)	8 (45)	9 (27)	10 (14)	11 (1)	12 (1)
Males and Females ..	333, 353	180, 180	129, 113	69, 71	7, 4	2, 10

8. *The decrease in the numbers of cases.*—The progression of the numbers of the families of various numbers of issue follows no simple law. In the "Who's Who" families, from 3 onwards to 10, each number is roughly of the order of one-half of the one preceding: this shows the rate of diminution with the class of persons considered, but has no general significance.

Although the number of cases are rather small, being only 5333 families in all, they indicate that, on the whole, the masculinity (duly weighted) diminishes initially with increase in the size of family, but that afterwards it is

oscillatory. This, perhaps, is best seen by basing the masculinity on the totals for families 1 to n. Thus:—

Families.. ..	1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12
Masculinity ..	500	79	40	84	125	74	56	54	65	63	65	59

It ought to be noted, however, that these "families" are not the total issue: in the Australian results given earlier they are. There is a difference in the Australian results for the living issue, and therefore probably also in the issues recorded in "Who's Who." So far as they can be taken to have any real significance, they show that the masculinity diminishes as far as families of issue three (see Section 10 hereinafter).

9. *Parkes' Peerage results.*—Quite recently A. S. Parkes discussed the sex-ratio of Peerage families of from 2 to 8, but there were only 1179 families in all.* He obtained the number of males per 10,000 of both sexes combined shown in the table hereunder (see his Table II., p. 211). From these the masculinity is given in the next lower line per 10,000.

Size of Family	2	3	4	5	6	7	8
Males per 10,000 Children ..	7081	6220	5622	5298	5431	5185	4845
Masculinity	4162	2440	1244	597	862	370	—310
Calculated masculinity	4162	2507	1254	403	—	—	—

These can be roughly represented as far as families of 5 by

$$(M - F)/(M+F) = 8678 - 2660n + 201\ n^2.$$

the masculinity being taken as the ratio of the difference of the males and females to their sum and n being the number of children in the family. This expression, however, quite fails beyond 5. For families of 6 to 8, the masculinity is sensibly 4425 — 586 n, which gives 909, 323 and — 263 instead of. 862, 370 and — 310, but it is quite wrong for the earlier numbers. Results such as these depending upon so small a total number of families as 1179 are of very little value. The Australian results, based upon

* Frequencies of Sex-combinations in Human Families by A. S. Parkes, B.A., Ph.D., Eugenics Review, Oct. 1924, pp. 211-216.

about 81.375 families, are better adopted to reveal the nature of the general law of diminution of masculinity with increase of family, if such a law exists.

An examination of the results clearly suggests that records for, say, 10 years instead of 3 are to be desired, and that it would be well if these were computed separately (a) from the families where the father has died, and (b) from families where the mother has died. It would also be well to compare the masculinities computed from the living issue, and from the deceased issue. Owing to the inclusion in the latter of so many lives of very short duration, where the danger of death in the case of males is sensibly greater than that in the case of females, a systematic difference is to be expected. This will now be considered.

10. *Difference of masculinity of living and deceased issue.*—It is somewhat remarkable that the records of deceased issue in Australia differ very markedly in masculinity from the records of the living issue, the registration of the fact being taken at the deaths of married male and married female parents. They are as follow :—

Families of		Living-Issue-		Deceased.		Masculinities per 10,000.			
		M.	F.	M.	F.	Living.	(Calc.)	Deceased.	All.
1	..	3775	8553	599	442	303	304	1508	453
2	..	7991	7706	1437	1022	182	218	1687	386
8	..	11701	11280	2452	1846	180	143	1410	376
4	..	14564	14274	8699	2663	101	80	1629	877
5	..	16174	16085	4591	8605	27	28	1208	266
ε	..	17722	17937	5443	4180	—103	—18	1312	247
7	..	18895	18576	6110	4677	+85	—42	1328	366
8	..	19026	19266	6560	5164	—63	—60	1105	231
9	..	17752	17996	6418	4945	—68	—67	1293	260

Thus, with the exception of families of six children, the living issue exhibits a diminution in masculinity throughout. The masculinities for the living issue are, roughly, about as given by the following formula, viz. :—

$$(M - F)/(M + F) = 401\tfrac{1}{3} - 103 \; n + 5\tfrac{2}{3} \; n^2$$

and the results by this formula are shown under the word "(Calc.)". No simple curve will represent exactly the

actual results. The masculinity of the deceased issue is more variable, but as the numbers in the family increase, the decrease is not so definite. The means of each three, however, are

1535, 1575, 1414, 1381, 1281, 1248, 1242,

and show that, on the whole, the decrease is fairly marked.

11. *Conclusions.*—The facts considered in all their bearings indicate the following:—

(a) That on the average large families will contain relatively more females than small families, but that this result is more definite for families of 1 to 6, after which possibly the masculinity is less well marked.

(b) That multiple-births markedly contribute to this, but are relatively so small in number that they quantitatively affect the general result but slightly.

(c) That a more extensive study is a desideratum.

(d) That the study should embrace separately the living issue, the deceased issue, and both combined.

(e) That it would be well also to compute the results from male-parent records and female-parent records separately, as well as in combination.

(f) That the definitive law can be expected to appear only when very large numbers of cases are studied.

(g) That consequently the possibility of a secular change with time can not yet be studied as it can with masculinity in general.

(h) That, finally, apparently the question deserves systematic study on a more extensive scale as offering an important contribution to a knowledge of the phenomena of sex-ratios in human reproduction.

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MOLECULAR SOLUTION VOLUMES AND ASSOCIATION.

By G. J. BURROWS, B.Sc., and A. E. JAMES, B.Sc.

(Read before the Royal Society of New South Wales, Sept. 2, 1925.)

In a previous communication (this Journal, vol. lvii., 118) results were given for the molecular solution volumes of various solutes in ethyl alcohol. It was there shown that in the case of a non-associated solute the difference between the observed molecular solution volume ϕ in alcohol and the volume ΣnA calculated from the atomic volumes was approximately constant, and equal to about 20 c.c. per gram molecule of solute (in dilute solution). In the case of associated solutes, however, this diffetence was invariably less than 20 c.c., the variation depending on the degree of association.

This investigation has since been extended to a study of solution volumes in methyl alcohol and acetone which, like ethyl alcohol, have comparatively high dielectric constants. It has been found that solutions in these liquids give results similar to those obtained with ethyl alcohol. In addition, solutions of certain of the same solutes in benzene and toluene have been examined. In the latter solvents, which are liquids of low dielectric constants and in which the tendency is for solutes to dissolve without decrease in molecular complexity, it was expected that the marked variations in volume-change observed in the case of ethyl alcohol solutions would vanish. Such has been found to be the case.

The results obtained for the molecular solution volumes
in the various solvents, including those already published
for solutions in ethyl alcohol, are summarised in the follow-
ing table. The figures in the second column under M.V.
are the values of the molecular volumes in the liquid state,
calculated from their densities at 30° or extrapolated from
values at higher temperatures; those in the third column
under ΣnA are the molecular solution volumes calculated
from the atomic volumes adduced by Traube from results
obtained for aqueous solutions. As stated in the previous
communication there is no reason to suppose that these
values are dependent on the solvent. The experimental
values of the molecular solution volumes are given under
ϕ; they were calculated by means of the usual equation
$\phi = \dfrac{g+m}{d_1} - \dfrac{g}{d_0}$, in which g is the weight of solvent
containing the molecular weight m in grams of the solute,
and d_0 and d_1 are the densities of the solvent and solution
respectively.

Solute	M.V.	ΣnA	Ethyl alcohol.	Methyl alcohol.	Acetone.	Benzene.	Toluene.
Bromobenzene,	106 0	80 0	103.0	104 3	103.0	105.7	105.0
Chlorobenzene,	102.0	80 0	100.0	101 5	101.5	102.6	102.0
Toluene,	107.0	86.0	106 8	107.0	107.5	108.0	—
Aniline,	91.7	74 5	85.2	85 5	85 3	90.8	91.5
Nitrobenzene,	102.0	78.0	98.5	99 8	99.0	—	101.0
o-Nitrophenol,	105.0	80 0	100.0	—	—	—	—
p-Nitrophenol,	103.0	80 0	95.0	—	—	—	—
p-Nitraniline,	—	82.5	92.5	—	—	—	—
m-Nitraniline,	106.0	82.5	96.3	98.7	94.0	—	—
p-Chloraniline,	106.0	85.0	95.0	—	—	—	—
p-Bromaniline,	—	85.0	100.0	—	—	—	—
p-Toluidine,	109.0	90.6	100.4	102.2	102.0	108.8	109 0
o-Nitrotoluene,	118.9	95.0	114.0	—	—	—	—
p-Nitrotoluene,	119.0	94.0	108 0	—	—	—	—
p-Chloracetanilide,	—	116.0	128.0	130.0	129.0	—	—
Benzene,	90.6	70.0	—	89 9	90.2	—	90.0

In several cases, owing to the very limited solubility of the
solute in benzene and toluene, values for ϕ in these liquids
could not be obtained. Of the solutes used in this work,
p-toluidine, p-nitrophenol, aniline and the substituted ani-

lines are known to be associated; the other solutes are generally considered to be non-associated. From the above table it will be noticed that:

(a) In every case the molecular solution volume of a solute is greater in toluene or benzene than in the alcohols or acetone. This is in agreement with the observations of various investigators in this field, that molecular solution volumes are greatest in non-associated liquids (*i.e.*, liquids of low dielectric constant).

(b) The molecular solution volumes in benzene and toluene are in close agreement with the molecular volumes of the solutes in the liquid condition at the temperature of the experiment. This would indicate that, within the limits of concentration considered in this investigation, a solute dissolves in a non-associated solvent without change of volume, irrespective of whether the solute is associated or not.

(c) The value of ϕ for a non-associated solute in ethyl alcohol, methyl alcohol or acetone is not very different from the value of the molecular volume of the liquid solute. The solution volumes in these cases are generally slightly lower than the corresponding volumes in benzene or toluene.

(d) In the case of associated solutes such as aniline and *p*-toluidine there is a marked difference between the molecular volume of the liquid solute and its solution volume in acetone or the alcohols.

These results indicate that the co-volume of any solute varies with the nature of the solvent, having a maximum value when dissolved in a solvent of low dielectric constant. The variation is small in the case of a non-associated solute, but considerable in the case of an associated solute.

Thus benzene dissolves in either toluene or methyl alcohol without any very marked change in volume, but when aniline or *p*-toluidine is dissolved in acetone or alcohol there is a marked contraction, although when dissolved in benzene or toluene there is no change, as shown by the close agreement between the values of the molecular solution volumes in these solvents and the molecular volume of the liquid solute.

Experimental.

In the following tables are given the observed densities (d_1) of solutions of the various solutes in methyl alcohol, acetone, benzene, and toluene, together with (ϕ) the molecular solution volumes calculated from these values. The concentrations of the different solutions are given under A as grams of solute per 100 grams of solvent.

	A	d_1	ϕ
Bromobenzene in methyl alcohol $(d_0 = 0.78280)$,			
	6.7910	0.80749	104.0
	15.0797	0.83521	104.5
Bromobenzene in acetone $(d_0 = 0.77995)$,			
	9.9753	0.81626	102.6
	11.6092	0.82161	103.2
Bromobenzene in benzene $(d_0 = 0.86657)$,			
	10.8072	0.90324	105.7
	13.6916	0.91231	105.8
Bromobenzene in toluene $(d_0 = 0.85148)$,			
	9.2384	0.88368	104.9
	10.2684	0.88695	105.1
Chlorobenzene in methyl alcohol,			
	3.5458	0.79299	100.5
	8.9509	0.80215	101.5
	14.6778	0.81346	101.4
Chlorobenzene in acetone,			
	8.2712	0.79819	101.3
	8.5301	0.79842	101.7

	A	d_1	ϕ
Chlorobenzene in benzene,			
	5.3992	0.87604	102.5
	9.6520	0.88277	102.7
Chlorobenzene in toluene,			
	8.5333	0.86683	102.4
	10.6487	0.87044	102.3
Toluene in methyl alcohol,			
	5.4581	0.78649	106.9
	8.3644	0.78807	107.2
	12.8551	0.79074	107.2
Toluene in acetone,			
	5.5188	0.78443	107.5
	5.6279	0.78453	107.4
	6.5662	0.78507	107.6
Toluene in benzene,			
	8.0842	0.86536	108.2
	8.7170	0.86536	108.0
Aniline in methyl alcohol,			
	7.3153	0.79822	85.2
	9.1012	0.80159	85.3
	15.6790	0.81335	85.9
Aniline in acetone,			
	7.2571	0.79626	85.0
	7.4128	0.79629	85.6
	8.0410	0.79769	85.3
Aniline in benzene,			
	7.5090	0.87597	90.8
	12.6083	0.88177	90.8
Aniline in toluene,			
	4.8119	0.85781	91.7
	11.8179	0.86635	91.5
Nitrobenzene in methyl alcohol,			
	11.5470	0.81355	99.7
	12.1046	0.81489	99.8
Nitrobenzene in acetone,			
	9.9403	0.80813	98.7
	11.0266	0.81708	98.9
Nitrobenzene in toluene,			
	6.8044	0.86800	101.3
	10.4014	0.87609	101.4

	A	d_1	ϕ
m-Nitraniline in methyl alcohol,			
	2.2542	0.79047	98.7
	3.2622	0.79384	98.7
m-Nitraniline in acetone,			
	0.6571	0.78322	93.0
	1.3328	0.78564	94.0
	1.5888	0.78660	93.4
	3.7476	0.79337	94.1
p-Toluidine in methyl alcohol,			
	4.8985	0.79219	102.0
	8.8660	0.79924	102.2
	13.1992	0.80637	102.4
p-Toluidine in acetone,			
	2.4042	0.78583	101.6
	5.7413	0.79093	102.2
p-Toluidine in benzene,			
	3.5196	0.87008	108.8
	7.1865	0.87360	108.7
p-Toluidine in toluene,			
	6.9860	0.85895	109.0
	9.5332	0.86145	109.0
p-Chloracetanilide in methyl alcohol,			
	3.5494	0.79374	129.5
	4.9551	0.79777	130.4
p-Chloracetanilide in acetone,			
	3.3159	0.79026	129.0
	3.9403	0.79220	128.7
Benzene in methyl alcohol,			
	7.7337	0.78837	89.9
	9.6253	0.78969	89.8
	11.6106	0.79096	89.8
Benzene in acetone,			
	5.4059	0.78392	90.2
	6.3747	0.78464	90.2
	6.7409	0.78484	90.2
Benzene in toluene,			
	7.0850	0.85237	90.8
	11.0594	0.85276	90.8

One of us is indebted to the McCaughey Research Fund Committee for a grant to defray the expense incurred in this   investigation.

The   Chemical   Laboratory,
       University   of   Sydney.

ACACIA SEEDLINGS, Part XI.

By R. H. Cambage, c.b.e., f.l.s.

[With Plates IV. - VIII.]

[Read before the Royal Society of N. S. Wales, October 7, 1925.]

SYNOPSIS:

NOCTURNAL MOVEMENT OF EARLY LEAVES.

CLOSING UP OF COTYLEDONS AT NIGHT.

DESCRIPTION OF SEEDLINGS.

Nocturnal Movement of Early Leaves.

The closing up at night and re-opening in the morning of leaflets on plants of the Family Leguminosæ, which includes the genus *Acacia,* is a matter of world-wide knowledge, but in previous papers of this series it has been pointed out that the phyllodes or modified leaf axes of certain Acacias also respond to changes from light to darkness, and, as evening approaches, close up towards the stem.* (Plate IV., Figs. 3 and 4.)

A popular expression used to describe the practice of a leaf in nightly closing up its leaflets is that the leaf goes to sleep. From observations made during last summer it has now been found that the early leaves of many species of *Acacia,* probably all, not only go to sleep, but it may also be said that they first go to bed and then to sleep.

The observations disclose that as the afternoon advances, the first to perhaps the tenth leaves of many *Acacia* seedlings gradually develop a downward movement radiating from the point of contact with the stem. This motion continues until the terminal portion of the leaf

* This Journ. Vol. LV. 106 (1921), and Vol. LVI. 181 (1922).
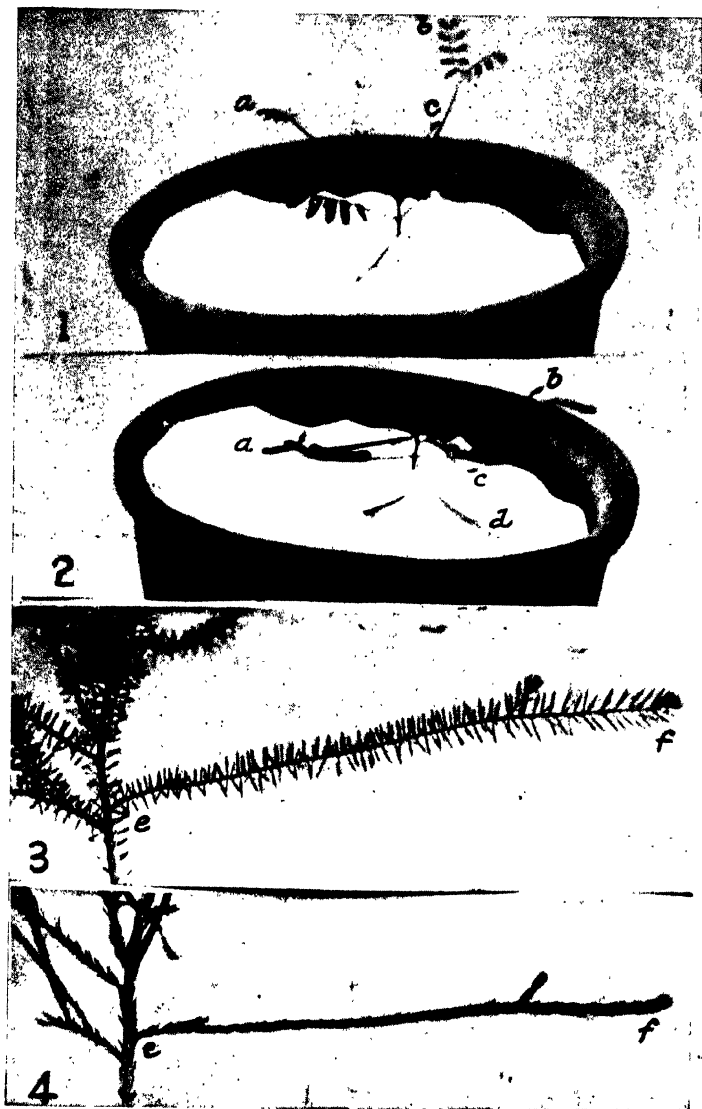
Acacia sclerosperma (1 – 2) *by day and night, seven-inch pot ;*
Acacia Conferta (3 – 4) *by day and night.   (e to f eight inches).*

is resting on the ground, while the leaflets are still spread open, and all of this takes place before sundown. After this, the leaflets gradually close up in pairs, and the leaves lie there till morning, when the leaflets again unfold and the leaves slowly resume their daily position, usually reaching their maximum height somewhere between 8.30 and 10 a.m., according to the sunlight available. (Plate IV., Figs. 1 and 2.)

This movement is more accentuated, and its amplitude or extent greater in the summer, especially on sunny days, than in the winter. The motive for this sinking down of the early leaves, and also of the closing up of the leaflets, is probably similar in both cases, and may be a natural provision for sheltering and protecting the delicate leaflets, as well as the tender and somewhat fragile young leaves. Obviously it is the lowest leaf which has the greatest proportion of its under surface resting on the ground when the leaves are depressed, the amount which comes in contact with the soil diminishing with each leaf in an ascending scale, until, in some plants the terminal point only, of perhaps a number seven leaf, will touch the earth, while number eight may just fail to reach it.

The feature is not confined to the genus *Acacia,* for leaves of *Mimosa pudica,* a Sensitive plant, were observed to act in a similar manner, and furthermore, it is well known that mature leaves and branchlets of this and other species of *Mimosa,* when touched at any time in the day, will at once collapse and sink down.

So great may be the amplitude of the movement of the leaf that in the case of one species of *Acacia* from Western Australia it was found to be 8.5 cm. for a number five leaf of the same length.

Measure of Force.—In view of the evidence of force or strength exerted by the young leaves in their efforts to accommodate themselves to the changing conditions of light and darkness, it was decided to secure some measure of such strength. Small loops of copper wire of known weight were placed on the end of the petiole at the base of the apical pair of pinnæ, and the height measured to which the terminal point of the leaf was carried. With a weight of 0.2276 grams, or 3.5124 grains placed at 6 cm. from the base of an *Acacia* leaf 8 cm. long, the terminal point of the leaf in one case was carried upwards 6.5 cm., or just over two and a half inches.

In the following table giving records of some of the leaf movements, the plants shown as species Nos. 2 and 5 were raised from seeds collected in the Gascoyne River district, Western Australia, by Mr. E. C. Andrews, and have not yet been identified. They belong to the section Uninerves, and somewhat resemble seedlings of *Acacia salicina*, while they show affinities with *A. sclerosperma.*

Name of species.	No of leaf.	Length of leaf.	Length of petiole.	Greatest width of petiole.	Extent of terminal movement without weight.	Extent of terminal movement with weight.	Weight in grams. (µ gr = 15 48284 grains)
Acacia							
trineura	6	6.7cm.	5cm.	7mm.	——	4.5cm.	0.1594
do	7	6cm.	4.3cm.	5.5mm.	——	4.5cm.	0.0762
do	7	6.5cm.	5.5cm.	9mm.	——	6.5cm.	0.1076
do	5	4cm.	2.4cm.	1mm.	4.5cm.	2.7cm.	0.1200
Sp. No. 2	5	8cm.	5.5cm.	3mm.	——	5cm.	0.1650
do	6	7.5cm.	6cm.	3.5mm.	——	6cm.	0.1808
do	7	8cm.	6cm.	4mm.	8cm.	6.5cm.	0.2276
Sp. No. 5	4	9cm.	6cm.	3mm.	——	1.5cm.	0.1808
do	5	8.5cm.	6cm.	2.5mm.	8.5cm.	5cm.	0.1650
do	6	8.5cm.	6cm.	3mm.	6cm.	4cm.	0.1594
do	5	8cm.	6cm.	2mm.	——	3cm.	0.1200
do	9	11cm.	9cm.	3.2mm.	——	4cm.	0.1200
concinna	?	12cm.	——	1.5mm.	——	5.5cm.	0.2276
do	?	12cm.	——	1.5mm.	——	3cm.	0.3320
Mimosa							
pudica	?	4.5cm.	3.7cm.	1.2mm.	5.2cm.	4.2cm.	0.3320
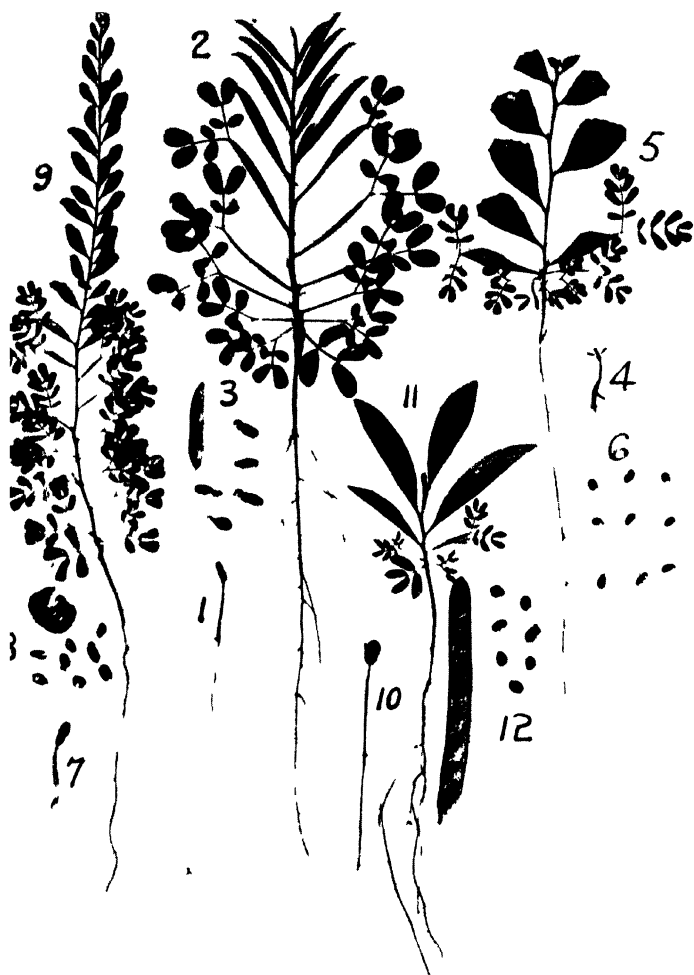
cacia pumila (1 – 3),   *Acacia bidentata* (4 – 6),   *Acacia obliqua* (7 – 9).
Acacia rhodoxylon (10 - 12).
Two-thirds Natural Size.

Closing Up of Cotyledons at Night.

In addition to the closing up of leaflets and phyllodes at night, it has recently been noticed that the same habit extends to the cotyledons of a few species, but so far it has been observed only in the case of species which have large fleshy petiolate cotyledons.

Acacia Farnesiana.—The terminal points of cotyledons were 2.60 cm. apart in the forenoon, and 2.10cm. at night.

A. Bidwilli.—The terminal points of four pairs of cotyledons gave the following measurements, forenoon and night respectively :—(a) 2.2cm., 1.2cm.; (b) 2.8cm., 2.5cm.; (c) 2.5cm., 1.8cm.; (d) 3cm., 2cm., the latter showing the combined movement of the two cotyledons to be 1cm.

Description of Seedlings.
Pungentes—(Plurinerves).

Acacia pumila, Maiden and Baker.[*] Seeds from Wentworth Falls, New South Wales (A. A. Hamilton), (Plate V., Numbers 1 to 3).

Seeds brownish-grey, oblong, about 4 mm. long, 2 mm. broad, 1.5 mm. thick.

Hypocotyl terete, reddish-green to brown and brownish-red, swelling into root, 1 to 2.3 cm. long, 2 to 2.3 mm. thick at base, 0.8 to 1.5 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 5 mm. long, 2.2 to 2.5 mm. broad, upperside dark green, underside reddish-brown, sometimes with one or two raised lines, becoming horizontal in a few days.

Stem terete, green, hirsute to pubescent. First internode 0.5 mm.; second to fifth 0.5 to 1 mm., sixth to eighth 1 to 2 mm.; ninth to tenth 2 to 7 mm.

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[*] Proc. Linn. Soc. N.S.Wales, Vol. XX., 385 (1895).

Leaves—No. 1. Abruptly pinnate, petiole about 4 mm.,.
glabrous to pilose; leaflets two pairs, oblong, shortly
mucronate, apical pair often obovate, 5 to 8 mm. long,
2.5 to 3.5 mm. broad, upperside green, underside pale
green; rachis 3 to 5 mm., with terminal seta; stipules small,
acuminate.

No. 2. Abruptly bipinnate, petiole 4 to 6 mm., upperside
sometimes channelled, with terminal seta; leaflets two pairs,
the basal pair oblong-acuminate, the apical pair obovate,
mucronate, 2 to 4 mm. long, 1.5 to 3 mm. broad; rachis 4
to 6 mm., with terminal seta.

Nos. 3 to 5. Abruptly bipinnate, petiole 6 mm. to 1.2
cm., glabrous to pilose; leaflets two pairs; rachis 4 to 8
mm.; stipules acuminate, 1 mm.

Nos. 6 to 9. Abruptly bipinnate, petiole 9 mm. to 2.2
cm., dilated up to 1 mm. broad, glabrous to pilose; leaflets
two to three pairs, the apical pair obovate; rachis 7 mm.
to 1 cm.

Nos. 10 to 12. These may be phyllodes, or abruptly
bipinnate, petiole 1.2 to 2.3 cm., dilated up to from 1
to 2.5 mm. broad, with two or three strong nerves, pilose;
leaflets two to three pairs, margins sometimes ciliate;
rachis 5 to 9 mm.; stipules 1.5 mm.

Nos. 13 to 18. Linear or lanceolate rigid pungent
pointed, slightly falcate phyllodes, 1.3 to 2.5 cm. long,
2 to 3 mm. broad, with three strong longitudinal nerves,
the central one often the most prominent, sometimes with
a much finer one between the central and lower veins,
margins ciliate to hirsute.

UNINERVES—(Triangulares).

ACACIA BIDENTATA Benth. Seeds from Wongan Hills,
    Western Australia (W. M. Carne). (Plate V, Numbers
    4 to 6.)

Seeds brownish-black to black, oblong-oval to obovate, 2.5 to 3 mm. long, 1.5 to 2 mm. broad, about 1 mm. thick.

Hypocotyl terete, reddish-brown above soil, 1 to 1.6 cm. long, 1.5 mm. thick at base, about 0.7 mm. thick at apex.

Cotyledons sessile, oblong, apex rounded, 3 mm. long, 1 mm. broad, upperside and underside yellowish-brown, with several raised longitudinal lines, remaining erect and falling in a few days.

Stem at first slightly angular, becoming terete, greyish-green, hirsute to pubescent. First internode 0.5 mm.; second to third 0.5 to 1 mm.; fourth to sixth 1 to 3 mm.; seventh to ninth 2 to 9 m.m.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair (in one instance only a single leaf appeared), petiole 2 to 3 mm., glabrous; leaflets two pairs, oblong-acuminate, 3 to 4 mm. long, 1 to 2 mm. broad, upperside green, underside paler; rachis 1 to 2 mm., with terminal seta; stipules small.

No. 2. Abruptly bipinnate, petiole 3 to 5 mm., glabrous to pilose, with terminal seta; leaflets two to three pairs, oblong, shortly acuminate, apical pair usually obovate, 2 to 3 mm. long, 1 to 2 mm. broad, upperside green; rachis 3 to 4 mm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 6 mm. to 1.5 cm. with a strong nerve along the lower margin in the case of No. 4; leaflets three to four pairs; rachis 4 to 8 mm.

Nos. 5 and 6. No. 6 may be a phyllode, or both may be abruptly bipinnate, petiole 1.3 to 2 cm., 2 to 5 mm. broad, with a main nerve along or close to the lower margin, and a second finer one extending for some distance above, the dilatation being almost wholly above the strong vein, glabrous to pilose; leaflets three to four pairs, up to 5 and

6 mm. long, 2.5 mm. broad, the terminal pair obovate; rachis 7 mm. to 1.3 cm.; stipules 1 mm., acuminate.

Nos. 7 to 10. No. 7 may be bipinnate, or all may be irregularly obovate to cuneate phyllodes, 1.5 to 2 cm. long, 6 mm. to 1 cm. broad, venation very similar to that of the petiole of No. 6, the upper portion usually protruding beyond the point of the main nerve, the margin sinuate with the appearance of having been eaten into by some insect.

UNINERVES—(Brevifoliæ).

ACACIA OBLIQUA A. Cunn. Seeds from Cassilis, New South Wales (W. H. Cullen). (Plate V, Numbers 7 to 9.)

Seeds black, irregularly oval to oblong-oval, 3 to 4 mm. long, about 2 mm. broad, 1 to 1.5 mm. thick.

Hypocotyl terete, greenish-brown above soil, 1.3 to 2 cm. long, about 2 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, oval-oblong to oblong, very slightly auricled, 5 to 6 mm. long, 3 mm. broad, upperside green, underside pale green, with raised line along centre.

Stem at first angular, becoming terete, green, pilose to hirsute. First internode 0.5 mm.; second 1 to 3 mm.; third and fourth 2 to 6 mm.; fifth to seventh 3 to 6 mm.; eighth to twelfth 2 to 7 mm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 4 mm., green, glabrous; leaflets two pairs, the basal pair oblong-acuminate or sometimes obovate, the apical pair obovate, 4 to 5 mm. long, 2 to 3 mm. broad, midrib distinct on underside, upperside green, underside paler; rachis 2 to 3 mm., with terminal seta; stipules minute.

No. 2. Abruptly bipinnate, petiole 5 to 6 mm., green, glabrous, with terminal seta; leaflets two to three pairs, obovate, the basal pair sometimes oblong-acuminate, 3 to 4 mm. long, 1.5 to 3 mm. broad, upperside green; rachis 4 to 5 mm., with terminal seta.

Acacia gladiiformis (1 – 3); *Acacia retinodes* (4 – 6).
Slightly Under One-half Natural Size.

Nos. 3 to 6. Abruptly bipinnate, petiole 3 to 6 mm.; leaflets two to four pairs; rachis 4 to 8 mm.; stipules flat acuminate scales, 1 mm. long.

Nos. 7 to 10. Abruptly bipinnate, petiole 5 to 8 mm., No. 10 sometimes dilated to 1 mm. broad, with a strong nerve along the lower margin, pilose to hirsute; leaflets four to five pairs, chiefly obovate, the basal pair often very small, margins sometimes ciliate; rachis 2 to 7 mm.

Nos. 11 to 14. These may be phyllodes, or abruptly bipinnate, petiole 7 to 8 mm. long, dilated up to 2 mm. broad, with a prominent vein along or near the lower margin, the lamina on the upper side in some cases extending beyond the terminal seta, sometimes as much as 2 mm., but in any such case one pinna may be missing, although the terminal seta is present; leaflets four to five pairs; rachis 6 to 8 mm.

Nos. 15 to 20. Obliquely obovate phyllodes, 5 mm. to about 1 cm. long, about 3 mm. broad, with a fairly conspicuous midrib below the centre, and a shorter secondary very indefinite nerve above diverging from the base, the midrib terminating in a small recurved point beyond which the upper portion of the lamina often extends.

UNINERVES—(Racemosæ).

ACACIA RETINODES Schlecht.   Seeds from Mount Lofty, Adelaide (E. H. Ising).   (Plate VI, Numbers 4 to 6.)

Seeds black, oblong, 4 to 5 mm. long, 1.7 to 2.5 mm. broad, 1 to 1.5 mm. thick.

Hypocotyl terete, pale green above soil, 8 mm. to 1.6 cm. long, about 1.5 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, oblong, apex rounded, 5 mm. long, 2.5 mm. broad, upperside green, underside pale green, with one or two raised lines.

Stem at first angular, becoming terete, green, glabrous. First internode 0.5 mm.; second to third 1 to 2 mm.; fourth to sixth 3 to 5 mm.; seventh to ninth 2 mm. to 2.8 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm., green, glabrous; leaflets three to four pairs, oblong-acuminate, 4 to 5 mm. long, 1 to 2 mm. broad, upperside green, underside paler; rachis 3 to 5 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 5 to 7 mm., with terminal seta, leaflets three to four pairs, oblong-acuminate, the apical pair sometimes obovate, 3 to 5 mm. long, 1 to 2 mm. broad; rachis 5 to 7 mm., with terminal seta.

Nos. 3 to 5. Abruptly bipinnate, petiole 6 mm. to 2 cm.; leaflets three to six pairs, rachis 8 mm. to 1.6 cm.

Nos. 6 to 8. No. 8 may be a phyllode, or all may be abruptly bipinnate, sometimes with two pairs of pinnæ, petiole 1.7 to 3 cm., with a strong nerve along the lower margin, sometimes dilated to 2.5 mm. broad and with a small gland in the case of No. 8; leaflets six to nine pairs, up to 9 mm. long; rachis 1.9 to 3.1 cm.; stipules flat, acuminate, up to 1.5 mm.

Nos. 9 to 12. Linear-lanceolate, prominently 1-nerved phyllodes, much narrowed towards the base, decurrent on the stem, with purple tips, becoming green.

<div align="center">UNINERVES—(Racemosæ).</div>

ACACIA GLADIIFORMIS A. Cunn. "Sword Wattle". Seeds from Cassilis, New South Wales (W. H. Cullen). (Plate VI, Numbers 1 to 3.)

Seeds jet-black, oblong to oblong-obovate, about 5 mm. long, 3 to 3.5 mm. broad, 1.5 mm. thick.

Hypocotyl terete, brownish-red above soil, 2 to 3 cm. long, about 2 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 to ˙7 mm. long, 3 mm. broad, upperside reddish-green, underside red, with three raised longitudinal lines, soon becoming revolute and cylindrical.

Stem at first angular, becoming terete, green to brownish-green, glabrous. First internode 0.5 mm.; second 0.5 to 1 mm.; third 1 to 2 mm.; fourth 2 to 5 mm.; fifth and sixth 2 mm. to 1 cm.; seventh to ninth 4 mm. to 1.6 cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 4 mm., often with gland on upper margin, glabrous; leaflets three to four pairs, oblong-acuminate, 5 mm. to 1 cm. long, 2 to 3 mm. broad, upperside often at first reddish-green, becoming green, underside red; rachis 5 mm. to 1 cm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 7 mm. to 1.1 cm., usually with gland, glabrous, with terminal seta; leaflets three to four pairs oblong-acuminate, the apical pair sometimes obovate, the basal pair often small, 2 to 9 mm. long, 1 to 4 mm. broad, upperside green, underside red to reddish-brown; rachis 6 mm. to 1.4 cm., glabrous, with terminal seta; stipules small, flat, acuminate.

Nos. 3 and 4. Abruptly bipinnate, petiole 1.5 to 4.4 cm., with gland; leaflets four to nine pairs, sometimes up to 1.2 cm. long and 5 mm. broad, the apical pair obovate; rachis 1.4 to 4 cm.

Nos. 5 and 6. Abruptly bipinnate, sometimes with two pairs of pinnæ, gland on upper margin, with strong nerve along lower margin, No. 6 may be dilated to 2 and sometimes 5 mm. broad; leaflets seven to thirteen pairs; rachis 1.7 to 5 cm.

Nos. 7 and 8. These may be phyllodes, or abruptly bipinnate, petiole 6.5 to 12.2 cm. long, sometimes up to ˙9 mm. broad in No. 7, and 1.1 cm. broad in No. 8, with

the midrib along or very slightly below the centre, and
a strong nerve along the margins, with a gland on the
upper margin, or sometimes six glands on No. 8; leaflets
seven to thirteen pairs; rachis 2.5 to 4 cm.; stipules 1 mm.
long.

Nos. 9 to 12. Linear-lanceolate phyllodes, from about
9 to 14 cm. long, 5 mm. to 1.5 cm. broad, much narrowed
towards the base, with a terminal small hooked point, the
midrib often slightly above the centre of the lamina as in
the case of *A. falcata* and which is not a common occur-
rence in early phyllodes,* the margins thickened, often
with three to five glands; in one case No. 8 had six and
a No. 10 had nine glands. Phyllodes above Nos. 10 or 12,
and sometimes earlier ones, curve upwards.

<div align="center">Uninerves—(Racemosæ).</div>

Acacia subulata Bonpl.   Seeds from Warialda, New
    South Wales (J. H. Maiden).   (Plate VII, Numbers
    1 to 3.)

Seeds dull black, oblong, the smaller ones oblong-oval,
4 to 6 mm. long, 3 mm. broad, 1 to 1.5 mm. thick.

Hypocotyl terete, brownish-green above the soil, 1.5 to
2.5 cm. long, about 1.5 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 mm.
long, 3 mm. broad, upperside green, underside pale green,
with a few raised lines, soon becoming horizontal and
revolute.

Stem at first angular, becoming terete, glabrous. First
internode 0.5 to 1 mm.; second 1 to 3 mm.; third 2 to 8 mm.;
fourth to fifth 4 mm. to 1.9 cm.; sixth to ninth 8 mm.
to 2 cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 5 mm.,
glabrous; leaflets three to five pairs, oblong-acuminate,

Acacia subulata (1 – 3) ; *Acacia sparsiflora* – 6)
Three-fifths Natural Size.

apical pair often obovate, mucronate, 4 to 8 mm. long, 1 to 4 mm. broad, upperside green, underside pale green; rachis 6 mm. to 1.4 cm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 1 to 1.7 cm., with terminal seta; leaflets three to four pairs, oblong-acuminate, apical pair obovate, mucronate, 2 to 7 mm. long, 1 to 4 mm. broad, upperside green; rachis 6 mm. to 1.2 cm., with terminal seta; stipules very small.

Nos. 3 and 4. Abruptly bipinnate, petiole 1.4 to 4 cm., sometimes with a gland on No. 4; leaflets four to seven pairs; rachis 1.2 to 2.4 cm.

No. 5. This may be a phyllode, or abruptly bipinnate, sometimes with two pairs of pinnæ, petiole 3.5 to 7 cm., with a strong nerve along the lower margin, a gland on upper margin; leaflets seven to eight pairs; rachis 1.6 to 2.5 cm.

Nos. 6 to 10. Very narrow linear phyllodes, 12 to 17 cm. long, 1 to 1.5 mm. broad, with a central nerve.

JULIFLORÆ—(Falcatæ).

ACACIA SPARSIFLORA Maiden.* Seeds from Eidsvold, Queensland (Dr. T. L. Bancroft, per J. H. Maiden). (Plate VII, Numbers 4 to 6.)

Seeds shiny black, oblong, about 5 mm. long, 2 mm. broad, about 1 mm. thick.

Hypocotyl terete, green to greenish-brown and brownish-red above soil, 2 to 3 cm. long, 0.8 to 1 mm. thick at base, 0.5 to 0.8 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 to 8 mm. long, 2 to 2.5 mm. broad, upperside green, underside pale green.

Stem at first angular, becoming terete, pilose to hirsute.

* This Journ., Vol. LIII., 221 (1919).

First internode 0.5 mm.; second 1 to 2 mm.; third and fourth 2 to 7 mm.; fifth to seventh 3 to 9 mm.; eighth to tenth 4 to 9 mm.

Leaves—No. 1.　Abruptly pinnate, petiole 3 to 5 mm., glabrous or with a few scattered hairs; leaflets two pairs, 5 to 8 mm. long, 2 to 4 mm. broad, oblong-acuminate to obovate, sometimes mucronate, upperside green, underside pale green to sometimes reddish-green; rachis 2 to 4 mm., with terminal seta.

No. 2.　Abruptly bipinnate, petiole 6 mm. to 1 cm., with a few scattered hairs, terminal seta present; leaflets two to three pairs, oblong-acuminate to obovate, 2 to 4 mm. long, 1 to 2 mm. broad; rachis 3 to 4 mm., with terminal seta; stipules small.

Nos. 3 and 4.　Abruptly bipinnate, petiole 1 to 1.9 cm., pilose to hirsute, dilated to 0.5 mm. broad; leaflets three to four pairs; rachis 3 mm. to 1 cm.; stipules up to 1.5 mm., flat, acuminate.

Nos. 5 and 6.　Abruptly bipinnate, petiole 1.5 to 3.2 cm. long, up to 7 mm. broad, with a fairly prominent nerve along or near the lower margin and several finer ones above, pilose, margins ciliate; leaflets three to five pairs; rachis 7 mm. to 1.1 cm.

Nos. 7 to 10.　Nos. 8 to 10 may be phyllodes, or all abruptly bipinnate, petiole 1.6 to 4 cm. long, up to 7 mm. broad, with a fairly prominent midrib near the centre of the lamina and numerous finer veins on both sides of it, pilose, margins ciliate; leaflets four to five pairs; rachis 6 mm. to 1 cm.

Nos. 11 to 15.　These may be phyllodes, or abruptly bipinnate, petiole up to 4.3 cm. long, and up to 9 mm. broad, pilose; leaflets five pairs.

Nos. 16 to 20. Lanceolate phyllodes, narrowed at both ends, often flexuose, 3 to 5 cm. long, up to 1 cm. broad, usually with a fairly prominent nerve along the centre, a second vein above, a little less prominent, and a third still less prominent below the central nerve, the rest of the lamina closely striated with very fine parallel veins, pilose, the margins slightly ciliate.

JULIFLORÆ—(Falcatæ).

ACACIA RHODOXYLON Maiden.* Seeds from Eidsvold, Queensland (Dr. T. L. Bancroft, per J. H. Maiden). (Plate V, Numbers 10 to 12.)

Seeds shiny black, oblong-oval to oval, about 3 to 4 mm. long, 2.5 mm. broad, 1 to 1.5 mm. thick.

Hypocotyl creamy to pale brown, 1.5 to 2.5 cm. long, about 1.5 mm. thick at base, 0.8 to 1 mm. at apex, spreading into flange at root.

Cotyledons sessile, auricled, oval-oblong, about 5 mm. long, 3 to 3.5 mm. broad, upperside green, underside pale green.

Stem at first angular, becoming terete, glabrous. First internode 0.5 mm.; second 0.5 to 1 mm.; third and fourth 1 to 2 mm.; fifth and sixth 2 to 3 mm.; seventh and eighth 3 to 5 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm.; leaflets two, rarely three pairs, 3 to 6 mm. long, 1 to 2.5 mm. broad, oblong-acuminate, the apical pair sometimes obovate, upperside green, underside paler; rachis 2 mm., with terminal seta.

No. 2. Abruptly bipinnate (in one instance this leaf was simply pinnate), petiole 2 to 5 mm., with terminal seta; leaflets two pairs, 2 to 5 mm. long, 1 to 2 mm. broad, oblong-acuminate, upperside green; rachis 2 to 4 mm., with terminal seta.

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* This Journ., Vol. LIII., 223 (1919).

Nos. 3 and 4. Abruptly bipinnate, petiole 4 mm. in No. 3, to 1.7 cm. in No. 4, dilated to 1 mm. broad in the case of the latter, with a prominent vein along the lower margin and a few much finer ones above, glabrous; leaflets two to three pairs; rachis 2 to 5 mm.

Nos. 5 to 8. These may be oblong-lanceolate, slightly falcate phyllodes, narrowed at both ends, from about 2 to 5 cm. long, up to 7 mm. broad, finely striate with numerous parallel veins, with the central nerve the most prominent, and sometimes one above and another below a little less conspicuous than the central vein.

<div align="center">BIPINNATÆ—(Botryocephalæ).</div>

ACACIA DEALBATA Link, "Silver Wattle". Seeds from Cooma, New South Wales (J. H. Maiden). (Plate VIII, Numbers 1 to 3.)

Seeds shiny black, oblong to obovate, 4 to 5 mm. long, 2.5 to 3 mm. broad, about 1.5 mm. thick.

Hypocotyl terete, pink to brownish-red above soil, 1.5 to 2.5 cm. long, about 2 mm. thick at base, 1 mm. at apex.

'Cotyledons sessile, auricled, oblong, apex rounded, 5 to 6 mm. long, 2 to 3 mm. broad, upperside green, underside reddish-brown, with one or two raised lines, soon becoming revolute and cylindrical.

Stem at first slightly angular, soon becoming terete, greenish-brown to reddish-brown, slightly hoary. First internode 0.5 to 1 mm.; second 2 to 4 mm.; third 4 to 7 mm.; fourth to sixth 5 mm. to 1.5 cm.; seventh to ninth 1.2 to 2.5 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 5 mm., green to greenish-brown and brownish-red, rarely with a small gland; leaflets four to five pairs, oblong-acuminate to obovate, 4 to 7 mm. long, 1 to 2 mm. broad, upperside green, underside pale green to red; rachis 5 mm. to 1 cm., with terminal seta.
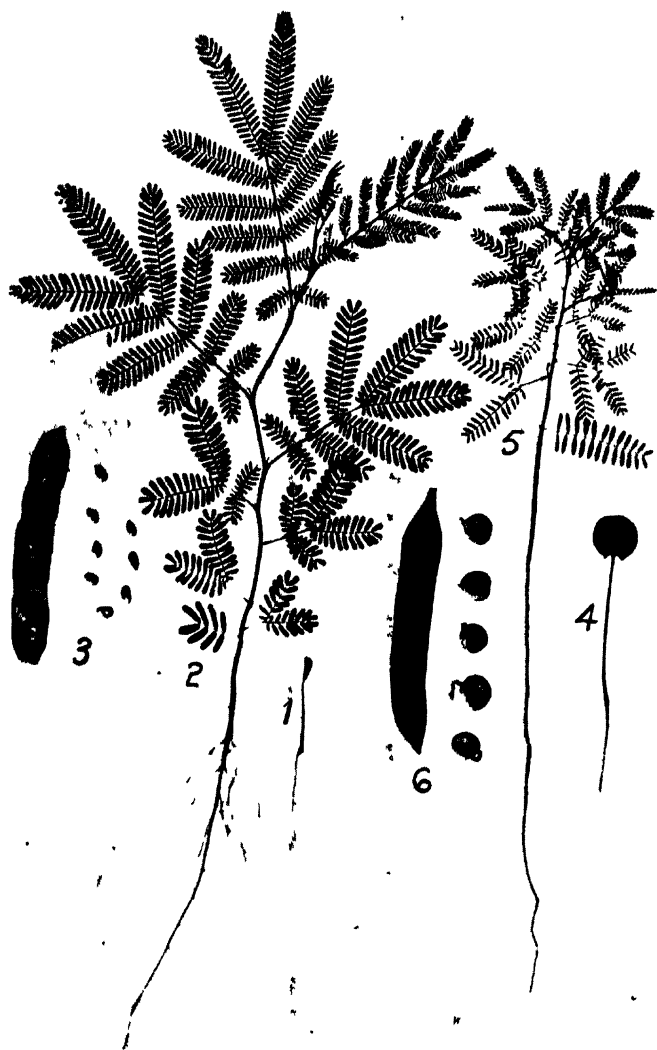
Acacia dealbata (1 – 3) ; *Acacia Bidwilli* 4 – 6).
About Half Natural Size.

'No. 2. Abruptly bipinnate, petiole 4 to 8 mm., sometimes with gland, glabrous, with terminal seta; leaflets five to ten pairs, oblong-acuminate to obovate, 3 to 5 mm. long, 1 to 2 mm. broad, upperside green; rachis 5 mm. to 1.6 cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, often with two pairs of pinnæ, common petiole 7 mm. to 1.9 cm., often with gland, pilose; leaflets seven to fourteen pairs; rachis up to 1.8 cm.

Nos. 5 and 6. Abruptly bipinnate, with from two to four pairs of pinnæ, common petiole 1.2 to 3.1 cm., with a few scattered hairs, a gland below the base of each pair of pinnæ; leaflets twelve to eighteen pairs, up to 6 mm. long, 1 to 1.5 mm. broad, oblong, shortly acuminate; rachis up to 3.6 cm.

Nos. 7 and 8. Abruptly bipinnate, with from three to seven pairs of pinnæ, common petiole 3 to 6 cm., leaflets twelve to twenty-seven pairs; rachis up to 3.8 cm.

Nos. 9 to 12. Abruptly bipinnate, with from four to ten pairs of pinnæ, common petiole 3.5 to 6.4 cm., a gland below the base of each pair of pinnæ but more distant from the basal pair, greenish-brown, hoary, with a minute pubescence; leaflets nineteen to thirty-two pairs, rachis up to 4.5 cm.

A later leaf may have twenty-seven pairs of pinnæ and forty-three pairs of leaflets, the leaflets being of an ashy grey colour, about 4 mm. long, 0.7 mm. broad.

GUMMIFERAE.

ACACIA BIDWILLI Benth. Seeds from Eidsvold, Queensland (Dr. T. L. Bancroft, per J. H. Maiden), Almaden and Georgetown, North Queensland. (Plate VIII, Numbers 4 to 6.)

Seeds light brown, oval to almost orbicular, flat, 7 mm.

to 1.1 cm. long, 6 mm. to 1 cm. broad, about 2 mm. thick, areole distinct, 4.5 to 6 mm. long.

Hypocotyl terete, creamy to very pale green, 2.5 to 4 cm. long, about 2 mm. thick at base, 1.3 to 1.8 at apex.

Cotyledons petiolate, petiole 1.5 to 2 mm., deeply auricled, fleshy, irregularly orbicular to almost square, 9 mm. to 1.4 cm. long, 8 mm. to 1.4 cm. broad, green on both sides.

The cotyledons of this species may partly close up at night, reducing the distance apart of their terminals as much as 1 cm. in some cases.

Stem terete, green to greenish-brown, glabrous. First internode 0.5 to 4 mm.; second 1 mm. to 1.4 cm.; third to fifth 3 to 6 mm.; sixth to eighth 4 to 6 mm.

Leaves—No. 1. Abruptly bipinnate, petiole 3 to 4 mm., glabrous; leaflets eight to twelve pairs, oblong-acuminate, 2 to 5 mm. long, 1 to 1.5 mm. broad, upperside green, underside pale green; rachis 1 to 2.6 cm., with terminal seta; stipules 1 mm.

No. 2. Abruptly bipinnate, petiole 5 to 8 mm., with terminal seta; leaflets eight to twelve pairs, 2 to 4 mm. long, 1 mm. broad; rachis 1 to 2 cm., with terminal seta.

Nos. 3 to 5. Abruptly bipinnate, usually with two pairs of pinnæ, common petiole 3 mm. to 1.2 cm., glabrous; leaflets nine to eleven pairs; rachis 8 mm. to 2 cm., stipules spinescent, 3 mm.

Nos. 6 to 9. Abruptly bipinnate, No. 8 often having three pairs of pinnæ and No. 9 four pairs, common petiole 6 mm. to 2 cm.; leaflets ten to thirteen pairs; rachis 9 mm. to 1.7 cm.; stipules spinescent, 4 mm.

The plants raised were not very robust, and most of them died during the winter months.

EXPLANATION OF PLATES.

PLATE IV.

1. *Acacia sclerosperma* ?, at midday, with leaves erect.
2. The same plant at nightfall, with leaves resting.
3. *Acacia conferta* at midday, with phyllodes spread.
4. The same twig at nightfall, with phyllodes closed up.

PLATE V.

Acacia pumila Maiden and Baker.

1. Cotyledons. Wentworth Falls, New South Wales, (A. A. Hamilton).
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

Acacia bidentata Benth.

4. Cotyledons and opposite pair of pinnate leaves. Western Australia, (W. M. Carne).
5. Opposite pair of pinnate leaves, bipinnate leaves and phyllodes.
6. Seeds.

Acacia obliqua A. Cunn.

7. Cotyledons, Cassilis, New South Wales, (W. H. Cullen).
8. Pod and seeds.
9. Pinnate leaf, bipinnate leaves and phyllodes.

Acacia rhodoxylon Maiden.

10. Cotyledons, Eidsvold, Queensland, (Dr. T. L. Bancroft per J. H. Maiden).
11. Pinnate leaf, bipinnate leaves and phyllodes.
12. Pod and seeds.

PLATE VI.

Acacia gladiiformis A. Cunn.

1. Cotyledons, Cassilis, New South Wales, (W. H. Cullen).
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

Acacia retinodes Schlecht.

4. Cotyledons and pinnate leaf. Adelaide (E. H. Ising).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Pod and seeds.

PLATE VII.

Acacia subulata Bonpl.

1. Cotyledons. Warialda, New South Wales, (J. H. Maiden).
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Pod and seeds.

Acacia sparsiflora Maiden.

4. Cotyledons and pinnate leaf. Eidsvold, Queensland, (Dr. T. L. Bancroft, per J. H. Maiden).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Seeds.

PLATE VIII.

Acacia dealbata Link.

1. Cotyledons. Cooma, New South Wales, (J. H. Maiden).
2. Pinnate leaf and bipinnate leaves.
3. Pod and seeds.

Acacia Bidwilli Benth.

4. Cotyledons, Eidsvold, Queensland, (Dr. T. L. Bancroft, per J. H. Maiden).
5. Pinnate leaf and bipinnate leaves.
6. Pod and seeds.

FURTHER OBSERVATIONS ON *STACHYS ARVENSIS*.

"STAGGER WEED" AS A CAUSE OF STAGGERS OR SHIVERS IN SHEEP.

By H. R. Seddon, D.V.Sc., W. L. Hindmarsh, B.V.Sc., M.R.C.V.S., and H. R. Carne, B.V.Sc.

(Read before the Royal Society of New South Wales, Oct. 7, 1925.)

Staggers is a term applied somewhat loosely to any condition wherein there is a staggery gait. In this State, however, there is a peculiar form of Staggers, also termed Shivers, which comes on when animals are driven. It has been shown by Dodd and Henry that such may be due to feeding on Marshmallow (*Malva parviflora*), or on *Lamium amplexicaule*. As will be seen in this paper, a third plant has more latterly been incriminated, and the purpose of this article is to record the factors which have a bearing on the development of Staggers or Shivers due to this third plant (*Stachys arvensis*).

Natural Order—Labiatae: (Mint, &c., Family).

Popular Description.—An annual herb ⅓ to 1½ feet high, with opposite leaves, oval, or occasionally almost heart-shaped at the base, and with wrinkled margins. The flowers are grouped in circles round the upper part of the square stem, one circle immediately above each pair of leaves. It is a native of Europe and Western Asia.

Botanical Description.—A weak, spreading, hairy annual Leaves small, petiolate, ovate-crenate. Flowers small, pale-purple, in false whorls of 2 to 6. Calyx with five nearly equal teeth as long as the tube. Corolla upper-lid erect, concave and entire.

From J. H. Maiden, The Weeds of New South Wales, pt. 1. (1920).

The fact that this plant might cause Staggers or Shivers. was first indicated in certain experiments conducted by one of us (W.L.H.), at Moss Vale in 1921. As these experiments involved only three sheep, only one of which showed definite shivers (held by us to be the best index of the condition), an endeavour was made at Narara in 1922 to confirm the previous results. These experiments were conducted by Hindmarsh, assisted by Mr. E. G. Griffiths, B.Sc., Assistant Chemist, but in this second series of experiments only negative results were obtained.

The following summary of the Moss Vale (1921) experiments may be detailed here:—In this experiment three adult sheep (one merino and two crossbreds) were employed and offered the weed *ad libitum*, no other food being allowed. The sheep were placed in a small yard and allowed water; supplies of the weed were freshly cut each day. The sheep did not eat the weed at all readily.

Sheep I.—Crossbred ewe, broken mouthed. Tested by driving on 14th day, it showed symptoms of both Staggers and Shivers. Tested again on the 21st day, it refused to travel more than 100 yards, and showed trembling. It died the same day.

Sheep II.—Merino ewe, aged. Tested by driving on the 21st, 27th and 28th days, travelled 3 to 4½ miles without showing definite symptoms of Shivers or Staggers, though there appeared to be some urinary irritation—a condition often seen but not invariably present in sheep which show definite Staggers.

Sheep III—Merino ewe, aged. Tested by driving on the 14th day, it travelled normally. On the 21st day (a 4 mile drive), it showed slight stiffness of action for the last mile of the journey. On the 27th day it travelled well for one mile, and then showed the signs of urinary irritation exhibited by the other sheep. At times whilst standing and straining to pass urine, the whole body trembled. It travelled a further 1½ miles, but gradually walked more slowly and went down. Similar symptoms were shown the following day. It was then killed.

In the Narara (1922) experiments, the following results were obtained:—

Pen I—Three adult sheep fed on freshly gathered plant, average 2.45 lbs. per day per sheep for 40 days. Tested—No symptoms of Staggers.

Pen II—Two adult sheep drenched daily with expressed juice and watery extract from freshly gathered plant. Average juice and extract from 6.77 lbs. plant per sheep per diem. Result—No ill effects.

Pen III—One adult sheep fed on residue after pressing, average 2.55 lbs. per diem. Residue mixed with lucerne chaff. Result—No ill effects.

Pen IV—Two adult sheep controls remained normal.

The following year (1923), it was decided (in view of the inconclusive results previously obtained), to conduct more extensive tests, such to be both at Narara and at the Glenfield Veterinary Research Station, which had meantime been established. These showed very definitely that

the weed was capable of inducing Staggers or Shivers, and the fact had been recorded by Seddon.

During certain of these experiments, more particularly those at the Veterinary Research Station, it became obvious that the effects of *Stachys* might be quite variable, even apart from individual idiosyncrasy in sheep (which will be discussed later), and the purpose of the present paper is to review the whole of the feeding experiments that have been conducted, and to offer an explanation for this variation in the effect of the plant.

Causes of variation in the effects of Stachys arvensis *in Sheep.*

(a) *Age of Animal.*

In the experiments recorded by Seddon, it was shown that when ewes and lambs were fed simultaneously, the lambs might show symptoms earlier than the adult sheep, or even to show symptoms whilst the adult sheep remained unaffected.

Thus in Experiment 1 (Glenfield), commenced 11th October, 1923, of three merino ewes with three well grown, recently weaned lambs, all the lambs showed symptoms on the fifth day of the experiment, whereas only one of the adult sheep showed them on that date, the other two not developing them till the seventh and twelfth days respectively.

In Experiment 2, with sheep from the same source as those used in the previous experiment, conducted at Glenfield, but not commenced until 10 days after Experiment 1, the two lambs showed slight symptoms, commencing on the 8th and 13th days respectively, but definite Shivers occurred in neither until the 25th day, on which date one exhibited Shivers, the other lamb being found dead in the pen on the same day; the adult sheep remained normal throughout, although the experiment was continued for 38 days.

(b) *Condition of plant.*

The following summary of all feeding experiments to date shows the date of commencement, and shows that the negative results were in general obtained in the late spring, whereas earlier (winter) experiments were positive.

Date of commencement of experiment.	Year.	Locality from which plant drawn.	Result of expt.	Minimal interval before symptoms appeared.
June 26,	1921	Moss Vale	Positive	14 days
July 23,	1924	Lisarow	Positive	6 days
August 23,	1924	Lisarow	Positive	13 days
September 26,	1922	Narara	Negative	—
September 26,	1923	Narara	Positive	12 days
October 11,	1923	Narara	Positive	5 days
October 21,	1923	Narara	Negative	—
October 30,	1923	Narara	Negative	—

As the seasons vary considerably from year to year, the condition of the plant on a given date may differ considerably in different years. A comparison of the experiments conducted in 1923 and 1924 shows that whereas the first experiments were invariably positive, in experiments conducted later in the same year the effect was more delayed or even entirely lacking. As successive feeding tests were first performed in 1923, it was only then that this fact was recognised. Thus in Experiment 3 (Narara, commenced 26th Sept.), and Experiment 4 (Narara, commenced 30th October), it was found in the first mentioned that Staggers was induced in three adult sheep in 12, 12 and 19 days respectively, whereas in the later experiment an adult sheep did not exhibit symptoms when tested repeatedly up to the 20th, 27th, and 33rd days after feeding commenced.

A similar result was shown by the adult sheep in Experiments 1 and 2 (quoted above), for whereas in the former symptoms were induced in three sheep in 5, 7, and 12 days respectively, in the latter no symptoms were induced, though the feeding was continued for 32 days.

It should be noted that the interval between these ex-

periments was quite small, being 34 days in the first
mentioned comparison and only 11 days in the second.
As the sheep used in this latter case were exactly com-
parable, it became obvious that some considerable change
must have occurred, and that relatively suddenly, for the
feeding to be attended with such diverse results.

It was noted that the plant used in the earlier of each of
these pairs of the experiment appeared green and succulent,
whereas in the later pair of experiments it was much
drier and of a yellowish colour.

It will be convenient here to give a short account of the
plant as we have seen it grow. It is peculiar in that though
an annual, it has not a direct seasonal growth, but springs
up whenever conditions are favourable, at any time of the
year, but is confined apparently to cultivated ground. It,
therefore, appears in quantity in orchard land, lucerne or
other cultivation paddocks, and in gardens during the
winter and early spring, and usually thrives from then on
until destroyed by cultivation in the late spring or by the
dryness of mid-summer. With the early autumn rains it
may spring up again, but the winter frosts are unfavourable
for it.

The plant commences to flower and seed when only a few
inches in height. Under favourable conditions, the plant
may remain green and show luxuriant growth (including
branches), and attain a height of up to 12 inches. Should
dry conditions prevail, however, it rapidly assumes a
yellowish colour, and such occurs irrespective of the size
or age of the plant. At the same time it naturally becomes
somewhat harsh.

Thus at any time from late winter to late spring, one
may find the majority of the plants either green and
succulent or yellowish and harsh, depending on whether
conditions are favourable for its growth or not. As

moisture in the soil is often influenced by cultivation pro-
cesses, these latter may have a bearing on the condition of
the plant.

An examination of rainfall records shows that just prior
to the period at which the plant was noted to lose its
potency, there was, in each year, a marked dry spell which,
with the rising temperature consequent on the advent of
summer, might prove unsuitable for the further growth of
the plant.

The variation in the effect of ''green'' and of
''yellowish'' plant here discussed might have been associ-
ated with death or wilting of the plant, and to determine
whether this was so or not, samples of the plant were dried
to hay and tested by feeding to sheep.

These experiments were planned as follows:—A quantity
of the fresh plant was fed and at the same time a similar
amount was weighed out and then sun-dried and fed to
animals of the same class as those used for the fresh plant.
The samples of dried weed were kept separate and fed in
proper rotation.

The results are shown in the following table:—

Ex. pt.	Year.	State of plant.	Sheep used.	Result.
2	1923	Fresh	1 adult sheep 2 lambs	Adult sheep—negative Lamb 1—symptoms 8th day Lamb 3—symptoms 13th day
5	1923	Dried (7 days)	1 adult sheep 2 lambs	Adult sheep—negative Lamb 1—symptoms 39th day Lamb 2—negative
6	1924	Fresh	3 lambs	Lamb 1—symptoms 16th day . Lamb 2—symptoms 18th day (died) Lamb 3—symptoms 24th day
7	1924	Dried (14 days)	3 lambs	Lamb 1—symptoms 10th day Lamb 2—symptoms 12th day Lamb 3—symptoms 12th day

Thus, in 1923 and 1924 lambs on both fresh and dried *Stachys arvensis* showed Staggers. Comparison of the effect of fresh and of dried *Stachys,* however, gave inconsistent results, for whereas in 1923 it appeared that the fresh weed was the more potent, in 1924 the reverse was the case.

Consideration of the manner in which these supplies of the weed had been dried showed that in 1923 the weed had been placed on jute bags of a rather open texture, which were lifted out into the sun daily, to hasten the drying process. In 1924 the bags used were placed in a shed and not disturbed until the weed was required for feeding. Further, it was observed that on lifting the dried (or drying) weed, the seed was easily lost, and thus in the 1924 experiments it was retained, whereas in the 1923 experiments it was probably largely lost.

Similar discordant results were obtained in connection with experiments designed to furnish a clue to the nature or location in the plant of the Staggers-producing principle as is shown in the following table:—

Experiment.	Material.	Animals.	Result.
2 (1923)	Fresh Stachys	2 lambs	Lamb 1—symptoms 8th day
			Lamb 2—symptoms 13th day
8 (1923)	Watery extract from Stachys	2 lambs	Lamb 1—symptoms 7th day
			Lamb 2—symptoms 15th day
9 (1923)	Residue	2 lambs	Lamb 1—negative (30 days)
			Lamb 2—negative (30 days)
6 (1924)	Fresh	3 lambs	Lamb 1—symptoms 16th day
			Lamb 2—symptoms 18th day (died)
			Lamb 3—symptoms 24th day
10 (1924)	Watery extract from Stachys	3 lambs	Lamb 1—negative (46 days)
			Lamb 2—negative (46 days)
			Lamb 3—negative (46 days)
11 (1924)	Residue	2 lambs	Lamb 1—symptoms 12th day
			Lamb 2—symptoms 12th day

In each year the "extracts" were prepared from similar material, and at the same time that the fresh plant was fed to the lambs. Further, the same quantity of weed was used for feeding in the fresh state, and for preparation of the "extract," the "residue" being the pressed plant residue remaining after the fluid "extract" had been removed by expression. As the lambs were of the same class, the experiments in each year become strictly comparable. (The "extract" was administered by the mouth, and for sustenance the lambs were provided with wheaten chaff; control sheep, receiving the same ration but neither drenched with extract nor fed with the weed, were included in the experiment.)

The 1923 results indicated that the Staggers-producing principle was present in the "extract," and not in the "residue"; the 1924 experiments as conclusively indicated the contrary.

These extracts were prepared by passing the weed through a mincing machine, adding tap water to thoroughly moisten the mass, allowing to stand overnight, and then expressing the fluid (so-called "extract"), by means of an ordinary meat press. An important difference in technique was made in each year, inasmuch as in 1923 the material was reduced to a much finer state than in 1924, the attrition in the former year being sufficient to break the seeds, whereas in the following year it was not. This result was due to different apparatus having been used.

These several variations in the effect of *Stachys arvensis* collected at different dates, of dried (and possibly deseeded) weed, and of extraction of thoroughly bruised and of simply chopped weed, all pointed to a possible common cause, namely the seed content of the plant.

That the plant commences to flower when only a few inches in height, and that the seeds are rapidly formed,

had not escaped notice, and one recognised the futility of attempting to collect the plant in quantity in the pre-flowering stage.

As a quantity of the dried *Stachys* was available, it was threshed, and two sheep were drenched (Experiment 12), with a watery extract of the seed as follows:—Fifty grams of the seed were thoroughly pounded in a mortar, and 400 c.c. of water added. It was allowed to stand overnight, and then filtered through muslin and drenched to lambs Nos. 34 and 35. This was repeated daily. The result was that both animals showed symptoms on the third day of drenching (S. 35 "shivered," S. 34 lagged).

An attempt was then made by threshing to remove the seed from dried supplies of the plant, as used in Expt. 7, the plant having now been drying for two months. (This experiment is not exactly comparable with Expt. 7, in which the first sample was weighed out on 30th July, for in the later experiments (Nos. 13 and 14), the first sample used was that put aside to dry on 10th August.)

After the 27th day of the experiment it became necessary to use dried weed from a bulk sample of "hay." The results of these experiments were as follows:—

Experiment 13.—Lambs fed on carefully *threshed weed.*
Remained normal after 40 days' feeding.

Experiment 14.—Lambs drenched with emulsified seeds from threshed hay. (Hay from same quantity of weed as that used in the fresh state for Expt. 7.)
One lamb shivered on 24th day, others remained normal.

The effect of drenching an emulsion of the seeds was then repeated, the material not being filtered. In the experiment (No. 15), 100 grams of seeds were administered

daily to each sheep in 400 c.c. of water (after crushing and allowing to soak in the water overnight). Result: Lamb 93 shivered on 3rd day and Lamb 94 on the 10th day.

An attempt was then made to remove the seed from *Stachys* and to feed the dried plant in as large quantities as would be consumed (about 1 lb. per day), a larger quantity than had been employed in Experiment 13. It was found impossible to remove *all* the seed, except by the tedious process employed in Experiment 13, a process not practicable with the larger quantities used in this experiment. The result of the experiment (No. 16), was that lamb 97 shivered on the 12th day and lamb 98 on the 15th day.

(c) *Quantity Fed.*

Obviously, this must play an important part. In nearly all our work, animals have been given as much as they would eat. With the fresh plant, the only case in which similar animals were fed at different rates was in 1923, when ewe 24 (Experiment 77), was fed with the weed *ad libitum* (consuming up to 6 lbs. daily), and developed symptoms of Staggers on the 12th day, and shivered on the 24th day, whereas sheep 38 (Experiment 2), fed 2 lbs. per day, remained normal. As one of these sheep was a cross-bred and the other a merino, it is perhaps unfair to compare them, though parenthetically it may be stated that both classes are susceptible, but whether equally so or not is unknown.

A more striking example is seen in the experiments wherein large quantities of seed were employed. In these two experiments shivering was manifested on the third day, whereas in no other experiment has an animal shown symptoms so rapidly. The quantity of seed given would be considerably more than that contained in the largest quantity of plant (fresh or dried) that a sheep could eat in the same time.

Further, when small quantities (average 8 grams per day), of seed were given (Experiment 14), shivering was manifest in only one of three animals, and then not until after 24 days' feeding, whereas of two similar sheep fed at the same time at the rate of 100 grams per day, one shivered on the third and the other on the 10th day.

(d) *Duration of feeding.*

No precise information is available on this point, but from the facts that on removal from the weed sheep recover rapidly (within 4 to 6 days) from the "Staggers" state, that in certain experiments sheep did not manifest symptoms until after as long as 40 days continuous feeding, it is probable that the action is a cumulative one, except in excessive doses large enough in themselves to induce the condition, e.g., large quantities of seed.

(e) *Distance Travelled.*

In very badly affected sheep, symptoms may be manifest almost immediately on submitting them to exercise. In the great majority of our cases, however, they have not developed until the animals have travelled at least one or two hundred yards, and not infrequently sheep have not exhibited the condition until they have been driven for between one and two miles.

(f) *Idiosyncrasy of Individual Sheep.*

It has always been our aim to include in each experiment as many sheep as possible, in order to avoid possible negative results due to individual insusceptibility as it appeared from the work of Dodd and Henry, on *Malva* and *Lamium*, that such might occur. Owing to the multiplicity of our experiments, it has rarely been possible to include more than three sheep in each experiment.

It is always possible that one sheep may eat less of the plant than another, and particularly is this likely to be so

in the earlier part of an experiment. Once the animals
have been got in the way of subsisting on the plant, such a
factor is not likely to play a large part and differences in
the effect on the sheep may be ascribed to idiosyncrasy.

There are a number of examples of this given in the
following table :—

Experiment.   Material.   Result.
17 (1924)   Fresh Stachys   Sheep 8, shivered 13th day
                              „   13, shivered 21st day
                              „   16, lagged from 13th to 21st day
                              „   14, remained   normal — ceased
                                        feeding after 21st day.
11 (1924)   Fresh Stachys   Sheep 67, shivered 8th day
                              „   71, shivered 10th day
                              „   72, shivered 19th day
                              „   68, shivered 21st day
14   Seed   Sheep 66, shivered 24th day
                              „   69, remained normal 35 days
                              „   70, remained normal 35 days

In other cases the results are much more uniform as
evidenced by the following :—

Experiment.   Material.   Result.
18 (1924)   Dried Stachys   Sheep 77, shivered 10th day
                              „   78, shivered 12th day
                              „   79, shivered 12th day
19 (1924)   Pressed residue Sheep 67, shivered 12th day
                              „   68, shivered 12th day

In each of the experiments quoted in these two tables the
sheep used were carefully selected, so as to be uniform as
regards breed and age. As they were driven together at
least every two days, it becomes evident that there is a
variation   in   susceptibility,   some   animals   exhibiting
symptoms much earlier than others.   This is in accord with
field experience of the disease.

(g) *Non-permanency of the Condition.*

In our experimental work it has generally been found
that once an animal has attained the condition in such a
severe form that it shivers during the first thousand yards

travelled, it will show symptoms at each subsequent driving,
provided that it is still fed with the weed.   The initial
symptoms under such circumstances are persistent lagging,
often passing on to complete refusal of the animal to travel
("knocking up").   Experience has shown that if such
animals are forced to travel, fatal consequences are liable
to occur, and for that reason such animals are generally
exempted from further driving.

It has happened, however, that sheep have shown
shivers one day and then on some, even may be on all,
subsequent drivings have travelled in a normal manner,
and that notwithstanding that they were still receiving
the weed.   In the experiments wherein an animal has
shivered one day, travelled normally at the next driving,
and then shivered again at the following driving such is,
we think, not to be ascribed to a complete or temporary re-
covery, but to an insufficiency of the test driving employed.
Direct evidence of this being the correct explanation has
been furnished by the result of driving an extra lap or
two such animals as might have been expected to show
symptoms—the extra distance usually serving to elicit
symptoms.   These cases, it should be noted, have only
occurred in animals in which symptoms have been pre-
viously manifest after driving a considerable distance, and
they were, therefore, we may conclude, not severely affected
with the condition.

The cases wherein there has been recovery whilst still on
the weed have been where at the commencement the fresh
plant has been fed, but where there has been evidence that
as the experiment progressed the plant became less harm-
ful.   An example of this is to be found in a record by
Seddon (loc. cit. Experiment 1, Sheep 1; compare Sheep
IV for fact of diminished potency of the weed).

Discussion.

From the foregoing it would appear that, as we early suspected, variation in the effect of the plant was related chiefly to two factors—

(a) Age of animal.

(b) Amount of seed contained in the plant fed.

The former is a clinical experience and its proof was furnished in the report earlier published.

The experiments in support of the latter are not so crucial as one would like, chiefly owing to the great difficulty of removing all the seed from samples of the dried plant and the impossibility of securing quantities of the plant in the short stage before seeding.

The recognition, however, of the fact that the Staggers-producing substance is present in quantity in the seed is an advance in our studies to determine the nature of the active principle and generally facilitates further work on the condition.

Summary of knowledge regarding Stachys arvensis *as a cause of Staggers or Shivers in sheep.*

It will be convenient now to give a general summary of the above, this being based upon field observations and the results of experimental feeding upon the plant.

1. *Stachys arvensis,* "Stagger Weed," is a cause of Staggers or Shivers in sheep. (Other plants capable of causing the condition are *Malva parviflora* (Marshmallow) and *Lamium amplexicaule* (one of the Nettle family).

2. For this effect to be produced the animals must have been eating the plant for at least four or five days.

3. The condition of Staggers or Shivers is observed only when the animals are driven or otherwise exercised. Thus they appear normal in the paddock or pen and show symptoms only when travelled. The amount of exercise

necessary to produce symptoms is variable: it may be only 50 yards or so, more usually it is from 200 to 500 yards, but it may be delayed until the animal has travelled over a mile.

4. Symptoms appear comparatively suddenly. The most prominent are a staggering gait and attacks of shivering. Frequently, but not invariably, animals lag behind the flock for a while before these attacks of Staggers or Shivers become manifest. Animals may show "Shivers" without any previous staggering. Again, they may at times stagger without showing "shivers."

Another symptom often but not constantly observed is frequent urination.

5. Following an attack the animal usually goes down and if allowed to rest a little while may get up and travel normally. More often any enforced driving leads to complete "knocking up" or further attacks of shivers.

6. Once having shown symptoms (lagging, knocking up, staggers or shivers) any enforced exercise is liable to cause sudden death of the animal, and the greatest care therefore has to be taken in droving a flock affected with the condition.

At times in our experimental work an animal has been found dead in the pen: it would appear therefore that severe exercise is not always necessary to bring about death.

7. The plant grows only in cultivated land (orchards, fallows, lucerne fields, etc.). It is a rapid grower when conditions are favourable, provides abundant herbage, and as otherwise it is not bad sheep feed, flocks might at times be depastured upon it. Under such circumstances therefore one might find that the whole or greater part of a flock becomes affected with the condition.

8. It occurs commonly in the following Pasture Protection Districts:—Maitland, Cumberland and Berrima.

So far as is known it does not occur in profusion in the main sheep districts. It would probably occur there, especially in the Tablelands, if more cultivation of crops for sheep feeding were carried out. It is never likely to be of importance in the central and western part of the State owing to the dry conditions.

9. The effects are most marked in young animals, particularly lambs. Ewes, even though not showing symptoms themselves, may transmit the condition through the milk, and thus even young lambs, not old enough to eat the plant in quantity themselves, may show symptoms.

10. The plant varies in its effects, and such is due chiefly to the amount of seed it contains.

11. The plant flowers and seed is formed when only a few inches high, and as the seed ripens it falls out. Thus, young, green, succulent, actively growing plants have been found to be most harmful.

Later the plant becomes drier, somewhat harsh, and yellowish in colour. The seed has then nearly all fallen out, and feeding at that stage may produce no ill effects. Soil conditions, particularly degree of moisture present, have a marked influence on the growth of the plant, and hence on its effect.

12. Generally speaking, it may be said to be most harmful in the late winter and early spring, and to decrease in stagger-producing action as spring advances until, drying off in the early summer, it becomes harmless. The amount of plant required to produce symptoms is therefore variable. In all experimental work wherein sheep were fed they received the plant alone—no other feed. Under such conditions lambs showed symptoms after eating at the rate of 1 lb. per day for five days. This was the young plant.

13. As mentioned before, the poisonous substance is present in greatest quantities in, if not entirely confined

to, the seeds. Drenching animals (fed on wheaten chaff) with an emulsion of large quantities of seed has led to symptoms in three days. *Stachys* hay from which *all* the seed had been threshed produced no ill effects.

14. If taken off the plant and placed on other feed (chaff, grass, etc.), affected animals recover in a few days. This is a very important fact, for in the case of an affected flock which it is desired to travel a distance, a change for say a week to a pasture free of stagger weed will allow them to recover and travel normally.

15. The majority of animals, as long as they are kept on the weed, provided it be at a noxious stage, retain the staggers condition, i.e., show symptoms on driving. A proportion however may recover. There appears therefore some individual tolerance, but this does not apply to the majority.

16. Animals that have shown symptoms and then recovered when placed on grass, have, when placed again on the weed, contracted staggers a second time, thus showing that they do not become immune.

17. In our experiments it has been found that over 90% of sheep are susceptible to the weed.

It is with pleasure we express our appreciation to Mr. H. G. White, Superintendent, Viticultural Nursery, Narara, and to Stock Inspector Hamilton, of Moss Vale, for the help afforded us in those experiments which were conducted in the field.

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THE FIXED OIL OF THE SEEDS OF THE "KURRAJONG."

(Brachychiton populneum, R.Br.; Syn. *Sterculia diversifolia,* G. Don),

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(Read before the Royal Society of New South Wales, Oct. 7, 1925.)

In a paper entitled "The Chemistry of the Kurrajong," by Mr. J. K. Taylor, B.Sc. (Agr.), published in the "Australian Forestry Journal," 1921, Vol. 4, p. 295, *inter alia,* the chemical and physical characteristics of a sample of Kurrajong seed oil are set forth, together with a description of the oil and its semi-drying properties. Since then the oil does not appear to have been further examined, and the present investigation was undertaken in order to determine its composition.

The botany of the species is described by Bentham in "Flora Australiensis" (Vol. 1, p. 229), as a tree attaining a height of 20-60 feet, the habitat extending from Gippsland in Victoria, throughout the eastern half of the Continent to the Gulf of Carpentaria in the Northern Territory. The tree is also fully described and figured in J. H. Maiden's "Forest Flora" (Vol. VII., p. 77).

The seeds which are contained in pods are fig-shaped, and consist of a white kernel enclosed in a black shell, the latter being covered with a yellow "furry" coating, which latter imparts an oiliness to the skin when handled. An average seed is 9mm. long, and weighs 0.13 gram.

Fixed Oil.—The oils obtained from two lots of seeds by means of solvents were reddish in colour and moderately viscous. They consisted of the glycerides of palmitic, oleic, and linolic acids, together with smaller quantities of free palmitic, oleic and linolic acids. A small quantity of unsaponifiable matter was also present, consisting of sito-sterol (phytosterol), and yellow colouring matter, the latter being derived from the coating of the seeds.

It may be mentioned here that the oil described by Mr. J. K. Taylor contained practically no free acids.

Experimental.—Two lots of seeds from trees growing at Dubbo were kindly supplied by Mr. R. J. Shuter of the Acclimatisation Area, Dubbo (Forestry Commission of New South Wales), in February, 1924, and in May, 1925. In each case the seeds were put through a mincer, and the moisture content determined in a portion of the meal. The oil content of the meal was determined in each case by extraction of portion of the meal with ether in a Soxhlet extraction apparatus. The remainder of the meal was then treated with solvents, ethyl ether being employed to extract the oil from the first lot of seeds; while the oil was obtained from the second lot by means of petroleum ether (boiling below 50°C.), in a continuous extractor. After removal of the solvent, oils were obtained as tabulated below :—

Date of collection.	Weight of seeds (grams).	Moisture content %.	Yield of oil.	
			By Soxhlet apparatus using ether as solvent.	In large extractor.
Feb., 1924	1137	6.4	23.4%	20.0% (using ethyl ether)
May, 1925	2330	10.4	23.9%	21.7% (using petrol'm. ether, B. Pt. below 50°

The oil obtained from the 1924 lot of seeds became semi-solid after the lapse of several days; whilst from the 1925 lot, after keeping some time at winter temperature (12-15°), a white crystalline deposit separated.   The physical and chemical characteristics of the crude oils were as follow:—

	1924 sample.	1925 sample.
Melting Point	30°	
Specific Gravity ..	0.9083 $\frac{1}{1}\frac{5}{5}$°	0.9203 $\frac{1}{1}\frac{5}{5}$°
Refractive Index ..	1.4676 at 20°	1.4709 at 20°
Acid Value	65.0	42.7
Saponification Value	198.0	192.8
Iodine Value (Wijs, 2 hours)	101.3	107.6
Unsaponifiable	1.1%	1.5%

Mixed fatty acids.—A quantity of the 1924 sample of oil (30 grams), was saponified with alcoholic potassium hydroxide, and the mixed fatty acids separated by means of sulphuric acid in the usual manner: 27 grams of mixed fatty acids being obtained equal to 90% of the crude oil. The following were the characteristics:—

Melting Point	33.5°
Specific Gravity	0.8908 $\frac{1}{1}\frac{5}{5}$°
Refractive Index	1.4548 at 40°
Iodine Value (Wijs, 2 hours) ..	100.9
Neutralisation Value	202.4
Mean Molecular Weight	277

Separation of "solid" and "liquid" acids.—The "solid" and "liquid" acids were determined quantitatively, using the modified method of Gusserow and Varrentrapp (Lewkowitsch, 1921, Vol. I, p. 556), which gave the following result:—Solid acid, 12%, and liquid acid 78%, calculated on the original oil.

Larger quantities of the respective acids were obtained for examination by the lead salt-ether method of Tortelli

& Ruggeri (L'Orosi, April, 1900), described by Lew-kowitsch (1921, Vol. I., p. 560); 40 grams of oil gave 7 grams of solid acid and 28 grams of liquid acid.

Solid acid.—This had a melting point of 50°, iodine value of 39, and neutralisation value of 209. After re-crystalli-sation from alcohol several times, the acid was obtained in a state of purity, melting at 62°, which melting point did not alter when the acid was mixed with a sample of palmitic acid from another source. It had a neutralisation value of 217 equal to a molecular weight of 258. The solid acid is, therefore, palmitic acid.

Liquid acid.—The liquid acid was of an amber colour, and had the following characteristics:—

Specific Gravity	0.9063 $\frac{15}{15}$°
Optical Rotation	$\pm 0°$
Refractive Index	1.4650 at 20°
Iodine Value (Wijs, 2 hours) ..	126.4
Neutralisation Value	197.2
Mean Molecular Weight	284

Insoluble bromides of the liquid acids.—A quantity (5 grams) of the liquid acids was dissolved in 50 cc. dry ether, the solution cooled to −20°, and saturated with bromine. The solution was allowed to stand overnight in a bath of ice and salt, but no insoluble bromides were preci-pitated, indicating that linolenic acid was absent. The excess of bromine was removed from the ethereal solution by means of sodium thiosulphate solution, and the ether allowed to evaporate, the last traces being removed in vacuo. The viscous residue was triturated with petroleum ether (boiling below 50°), at −20°, and the insoluble preci-pitate filtered off, and washed with cooled petroleum ether; 1.6 grams of bromide were thus obtained equivalent to 15 per cent. of linolic acid. The bromide crystallised from a

mixture of ether and petroleum ether in glistening needles, melting at 115°, and when mixed with a sample of linolic tetrabromide from another source, the melting point did not alter; 0.1385 gram gave 0.1722 gram Ag.Br; Br. = 52.9%. Linolic tetrabromide $C_{18}H_{32}O_2Br_4$ contains Br. = 53.33%.

The liquid bromide remaining after the removal of the petroleum from the filtrate consisted of a clear, viscous mass. The bromine content was determined by boiling with concentrated nitric acid and silver nitrate (J. Amer. C.S., Vol. 42 (1920), p. 1199); 0.4266 gram gave 0.3994 gram Ag.Br; Br. = 39.8%. Since oleic dibromide contains 36.18% Br., the liquid bromides apparently consist of oleic dibromide in admixture with a small quantity of linolic tetrabromide.

Oxidation of liquid acids.—The liquid acids were oxidised in alkaline solution with potassium permanganate (Lewkowitsch, 1921, Vol. I, p. 575) :—10 grams were dissolved in a solution of 4.5 grams of potassium hydroxide in 12 cc. of water, and the resulting soap was dissolved in 600 cc. of water; 600 cc. of an aqueous 1½% solution of potassium permanganate were added slowly with constant agitation, the temperature of the reaction being kept at 0°. The precipitated manganese dioxide was dissolved in sulphurous acid, and the liquid allowed to stand overnight, then filtered, the precipitate dried (9 grams), and the latter shaken with 1,000 cc. cold ether, filtered, and the solution concentrated to small bulk; on cooling, crystals separated as glistening laminae, which after crystallisation from hot alcohol, melted at 133°. The substance gave the following results on analysis: 0.0672 gram gave 0.0707 gram H_2O and 0.1684 gram CO_2; C = 68.34%, H = 11.68% : 0.1501 gram required 0.0269 gram KOH for neutralisation, equivalent to a molecular weight for a mono-basic acid of

313. Dihydroxystearic acid ($C_{18}H_{36}O_4$), requires C = 68.3%, H = 11.4%, and has a molecular weight of 316. The acid is, therefore, dihydroxystearic acid resulting from the oxidation of oleic acid.

The substance (3.3 gram), insoluble in cold ether, was purified by recrystallisation from dilute alcohol, and finally from 95% alcohol, microscopic crystals being obtained which melted at 164°. This melting point was not raised by further recrystallisation, and was apparently a-sativic acid, which is isomeric with the β form melting at 173°.

The acid gave the following results on analysis:—0.1046 gram gave 0.1004 gram H_2O and 0.2372 gram CO_2; C = 61.85%, H = 10.66%.

0.1492 gram required 0.0241 gram KOH for neutralisation, equivalent to a molecular weight for a mono-basic acid of 347.

$C_{18}H_{36}O_6$ requires C = 62.0% and H = 10.4%, and has a molecular weight of 348.

The acid is, therefore, a-tetrahydroxystearic acid resulting from the oxidation of linolic acid.

Determination of the free acids.—In the work detailed above, the free and combined acids were determined together. In order to determine the exact composition of the free acids present in the crude oil, a quantity of the 1925 sample of oil was treated as follows: 100 grams of the oil were shaken with four successive portions of 100 cc. alcohol, until the acid value of the oil remained unchanged. The acid values after the several agitations, were respectively 21, 15, 7.5 and 4.8, the value remaining constant at the latter figure. The free acids, together with a quantity of the neutral oil, were recovered from the alcoholic solution by removing the solvent, 29 grams of a

light brown fat being obtained, which had an acid value of 126. The fat was dissolved in 30 cc. alcohol, and exactly neutralised with aqueous $2N$ KOH, diluted with an equal volume of water, and the solution agitated with ether. By this means 8.5 grams of neutral oil were extracted. The soap solution was then decomposed with dilute sulphuric acid, and 15.5 grams of mixed fatty acids were obtained, which melted at 35° and had a neutralisation value of 196. The solid and liquid acids were prepared from 12 grams mixed fatty acids, by the lead salt-ether method, 2.8 grams of solid acid and 8.4 grams liquid acid being obtained.

Solid acid.—The solid acid was recrystallised several times from hot alcohol and melted at 62°, which melting point did not alter when the acid was mixed with a sample of palmitic acid from another source.

It had a molecular weight of 260. The solid acid is, therefore, palmitic acid.

Liquid acid.—The liquid acids were treated with bromine as described above, no ether insoluble bromides being obtained; 2.6 grams gave 1.2 grams bromides insoluble in petroleum ether equal to 21.6% linolic acid. The bromide after purification melted at 114.5°.

0.103 gram gave 0.1236 gram Ag.Br.; Br. 51.1%. Its identity with linolic tetrabromide was confirmed by the method of mixed melting point. The bromine content of the liquid bromide after separation of the tetrabromide was 39.28%, indicating oleic dibromide mixed with a small quantity of linolic tetrabromide.

The free acids, therefore, consisted of palmitic, oleic and linolic acids.

Neutral oil after removal of free acids.—The oil had the following characteristics :—

Specific Gravity	0.9214 $\frac{15^\circ}{15^\circ}$
Refractive Index	1.4709 at 20°
Acid Value	4.8
Saponification Value	195.6
Iodine value (Wijs 2 hours) ..	108

The solid and liquid fatty acids were prepared in the usual manner, and examined, the results being identical with those obtained with the 1924 sample of crude oil. A quantity of the liquid acids prepared from the 1925 sample of oil was oxidised with potassium permanganate as described above, whereby dihydroxystearic acid was obtained, together with the two isomeric tetrahydroxystearic acids, α- and β sativic acids, melting at 164° and 173° respectively. The combustion figures and molecular weights were identical. It would appear from this result that two forms of linolic acid are present in this oil. (See H. Meyer and R. Beer, Monatsh, f. Chem. 1892, 326.)

Unsaponifiable material.—The material extracted from aqueous solutions of the saponified oils by means of ether, was reddish in colour, and after standing some time, crystals appeared throughout the viscous mass. After repeated crystallisation from alcohol, tufts of crystals were obtained which melted at 133°. A drop of the alcoholic solution was allowed to crystallise on a microscopic slide, and when viewed through the microscope had the tufty crystalline appearance characteristic of sitosterol (phyto-sterol). The crystals gave the usual colour reactions characteristic of sitosterol or cholesterol. The crystalline portion of unsaponifiable material is, therefore, sitosterol.

Stearoptene.—The crystalline deposit which had separated from the crude oil after standing for some time was collected on a filter, and purified by crystallisation from absolute ethyl alcohol. A white crystalline solid was thus

obtained, which melted at 65°. It did not possess an acid value, and had a saponification value of 206. Palmitin melts at 65°, and has a saponification value of 208.8.

Tests for alkaloids.—The usual tests for the presence of alkaloids in the oils gave negative results, thus confirming Taylor's tests for the presence of those bodies.

The composition of the oil places it among oils of the semi-drying class.

My best thanks are due to Mr. A. R. Penfold, F.A.C.I., F.C.S., Economic Chemist, for advice and assistance in this investigation, and to Mr. F. O'Donnell, Laboratory Assistant, for assistance in extracting the oil from the seeds.

NOTES ON THE PRINCIPAL INDIGENOUS TIMBERS OF THE NATURAL ORDER SAXIFRAGEÆ.

By M. B. WELCH, B.Sc., A.I.C.

With Plates IX -XIII.

(Read before the Royal Society of New South Wales, Oct. 7, 1925.)

The Natural Order Saxifrageæ occurs almost throughout the whole of the world, either as herbaceous types, principally in the northern hemisphere, or as shrubby or arborescent species which are chiefly sub-tropical or tropical. Bentham[1] records twenty genera in Australia, of which twelve are endemic and many are monotypic.

In the eastern states of Australia, and more particularly in New South Wales and Queensland, several genera are of considerable economic importance as timber producing trees. The following genera reach large tree size, *Quintinia, Polyosma, Callicoma, Ceratopetalum, Schizomeria, Ackama, Weinmannia* and *Geissois,* and are of commercial interest.

There has been a considerable divergence of opinion as to the genera comprising the Saxifrageæ, e.g., Engler and Prantl[2] place the genera *Geissois, Ackama, Schizomeria, Ceratopetalum, Weinmannia* and *Callicoma* in the Natural Order Cunoniaceæ, whilst *Eucryphia,* placed by Bentham, l.c., in the Saxifrageæ is put in a new order, the Eucryphiaceæ. Bentham and Hooker[3] regarded the latter genus as belonging to the Rosaceæ. Similarly, there has been some dispute as to the species comprising the genera *Geissois* and *Weinmannia;* according to some writers

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(1) Bentham—Flora Australiensis, vol. ii., London, 1864.
(2) Engler und Prantl—Die Naturlichen Pflanzenfamilien.
(3) Bentham and Hooker—Genera Plantarum, London, vol. i., 1862-1867.
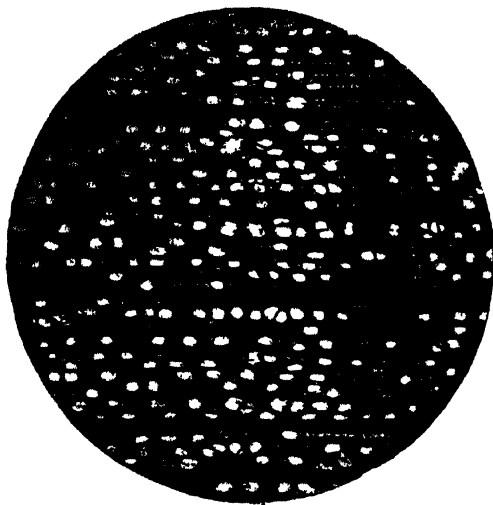
Fig. 1.—*Quintinia Sieberi.*
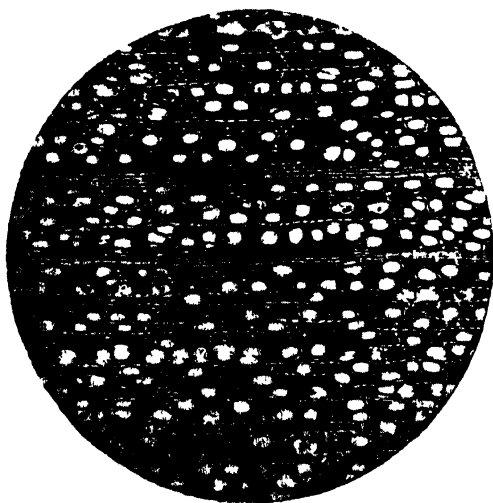
Fig. 2 —*Polyosma Cunninghamii*

Weinmannia lachnocarpa is placed under *Geissois*, according to others *Geissois Benthami* is placed under *Weinmannia*. In this paper it is proposed to follow the nomenclature used by Baker[4].

With the exception of *Weinmannia lachnocarpa*, of which the structure was described by Baker, l.c., there is little information available as to the anatomy of these woods, and it is proposed to describe them in some detail, together with a brief description of their macroscopical characters and uses.

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QUINTINIA SIEBERI, A.DC.

Opossum Wood, Corkwood, Pink Alder.

(Plate IX., Fig. 1.)

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A medium sized tree found in the brushes of eastern New South Wales, from near the Victorian border into southern Queensland. The wood is pinkish brown to reddish brown in colour, close textured, light in weight, about 32lbs. per cubic foot. It possesses no very distinctive figure, except for a rather prominent ray when quarter-cut. There is no distinct sapwood. Hardness = Moderately soft.*

Uses.—Not usually available in large quantity, but easily worked and very suitable for interior joinery, e.g., mouldings, linings, etc.

Macroscopical characters.—Pores very small, crowded, almost indistinguishable with the naked eye. Soft tissue not apparent. Rays of two kinds, the larger somewhat conspicuous on end section, but prominent on a radial face; the smaller scarcely perceptible. Growth rings inconspicuous.

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(4) R. T. Baker—Hardwoods of Australia, Sydney, 1919.
* The description of hardness is comparative only, and is obtained by measuring the depth of the impression made by a falling weight.

Microscopical characters.—Pores fairly evenly distributed, usually single or in small groups of rarely more than 3, not in radial rows; single pores irregularly elliptical; radial diameter 35–90μ, mean 55μ, tangential diameter 30–70μ; mean 45μ; vessel segments 1,000–1,350μ; walls 2–3μ; end perforation strongly scalariform, up to 70 cross bars; lateral pits irregularly crowded, slit-like, border elliptical or almost circular, often scalariform in contact with rays; pores per square mm., 65. Wood fibres moderately thick walled; average diameter 30μ; length 1,500–2,250μ; walls 4–6μ; lateral pits slit-like, often somewhat bordered; cells often becoming tracheidal, with rather crowded pits. Wood parenchyma fairly abundant, scattered or paratracheal, or in short metatracheal bands, never more than 1 cell in width. Multiseriate rays heterogeneous, often aggregate up to 2000μ in height, and 300μ in width; uniseriate rays 2-20 cells in height, often almost homogeneous; cell walls thick, prominently pitted; cells usually filled with dark contents; 10-14 per mm. of transverse section.

Alcoholic extract yellow; no fluorescence on adding water, no turbidity; no evidence of flavone; greenish colour with ferric chloride.

Burns with little ash, chiefly unburnt carbon.

POLYOSMA CUNNINGHAMII, Benn.

Feather Wood.

(Plate IX., Fig. 2)

A medium sized tree found in the coastal brushes of New South Wales and Queensland.

The wood is pale yellowish in colour, close textured and of medium weight, about 43 lbs. per cubic foot. It possesses, when quarter cut, a figure approaching that of

New South Wales Maple, *Villaresia Moorei.* Hardness = Moderately soft.

Uses.—Interior joinery, cabinet work, handles, turnery, etc. It is rarely seen on the Sydney market.

Macroscopical characters.—Pores very small, scattered, almost indistinguishable with the naked eye. Soft tissue not apparent. Rays of two kinds, the larger ones light in colour and conspicuous on end section, smaller rays inconspicuous. Growth rings indistinct.

Microscopical characters.—Pores fairly evenly distributed, usually single or in groups of 2 or 3, rarely in radial rows; single pores irregularly elliptical; radial diameter 55–110μ, mean 90μ; tangential diameter 30–75μ, mean 55μ; length of vessel segments $1{,}200$–$1{,}650\mu$; walls 4μ; end perforation strongly scalariform; bars numerous, up to 50; lateral pits crowded, bordered, elliptical or almost circular, opening slit-like, often scalariform in contact with rays; number per sq. mm., 60. Wood fibres very thick walled; average diameter 25μ; exceptionally long, $1{,}800$–$3{,}000\mu$; walls 8–14μ; pits slit-like, slightly bordered. Wood parenchyma fairly abundant, usually scattered or paratracheal, more rarely in short metatracheal rows, never more than 1 cell in width. Multiseriate rays heterogeneous up to $6{,}000\mu$ in height and 60μ in width; uniseriate rays 3-30 cells in height, almost homogeneous; all cells thick walled, pitting prominent; 8-11 rays per mm. of transverse section.

Alcoholic extract almost water white; slight bluish fluorescence with water, no turbidity; no evidence of flavone; very little alteration with ferric chloride.

Burns to dark grey ash, little unburnt carbon.

CALLICOMA SERRATIFOLIA, Andr.

Black Wattle, Coachwood, Butterwood.

(Plate X., Fig. 3.)

A medium sized tree found in the coast and tableland districts of New South Wales, from Clyde River into southern Queensland. Although usually a small tree in the watercourses near Sydney, it often reaches a large size in the northern rain forests.

The wood is pale to pinkish brown in colour, close textured, moderately heavy, weight per cubic foot about 40 lbs. It is without very distinct markings, except for a ribbon grain effect when tangentially cut, due to alternating bands of dark and light coloured tissue. There is no distinct sap-wood. Hardness = Moderately hard.

Uses.—It is rarely seen on the market, but should be suitable for brush stocks, chisel and small handles, turnery, interior joinery, etc.

Macroscopical characters.—Pores very small, crowded, almost indistinguishable with the naked eye. Soft tissue not apparent. Rays fine, numerous, inconspicuous on end section, conspicuous on a radial face. Growth rings not very prominent, but marked by narrow zones almost devoid of pores.

Microscopical characters.—Pores very numerous, very evenly distributed, in spring wood, usually single, rarely in short oblique rows of 2 or 3; single pores elliptical or irregular in shape, often with the larger axis tangential; radial diameter 35-90μ, mean 55μ; tangential diameter 30–60μ, mean 45μ; vessel segments 450–900μ; walls 2–3μ; end perforation strongly scalariform, bars up to 40 in number, no simple perforations; lateral pits crowded, slit-like, border elliptical, scalariform in contact with rays; average number per sq. mm., 125. Wood fibres moderately
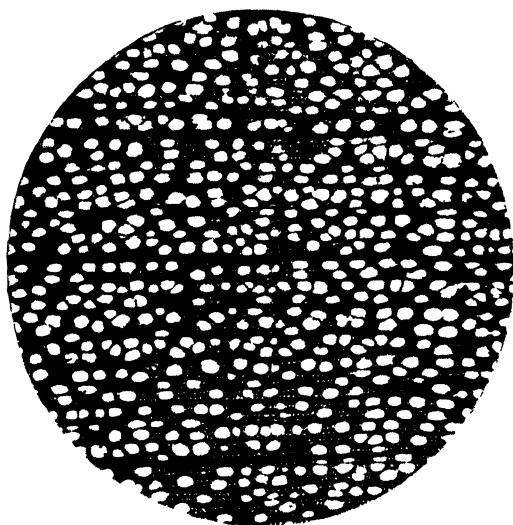
Fig. 3.—*Callicoma serratifolia.*
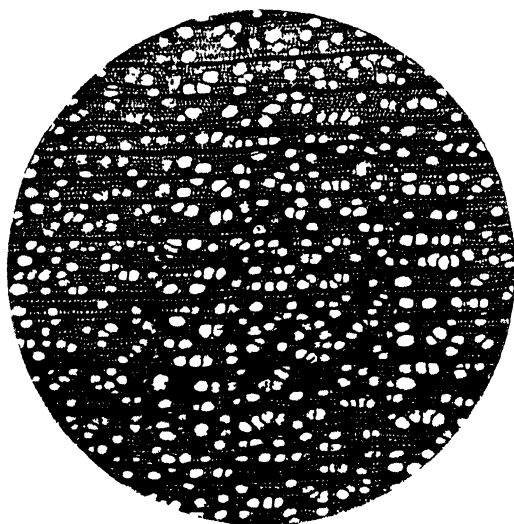
Fig. 4.—*Ceratopetalum apetalum.*

thick walled, mean diameter 25μ; length 800–1,350μ; walls
4–7μ; lateral pits slit-like, often bordered; cells show
transition to irregularly shaped tracheids with numerous
pits. Wood parenchyma not abundant, usually scattered
or paratracheal, or in short metatracheal bands, not more
than 1 cell in width. Multiseriate rays heterogeneous, up
to 1,000μ in height and 40μ in width; uniseriate rays 2-10
cells in height, often almost homogeneous; cells thick walled
and prominently pitted, usually with dark contents; 12–15
rays per mm. of transverse section.

Alcoholic extract deep reddish brown, no fluorescence on
adding water, no turbidity; no evidence of flavone; deep
brownish green with ferric chloride.

Burns to grey ash, little unburnt carbon.

CERATOPETALUM APETALUM, D. Don.

Coachwood, Leather Jacket, Lightwood.

(Plate X, Fig. 4.)

A large tree found chiefly in the brush forests of coastal
New South Wales, almost from north to south.

The wood is pale brown to pinkish brown in colour, close
textured, of moderate weight, about 40 lbs. per cubic foot.
It is usually figured, particularly when cut tangentially,
by the presence of darker coloured longitudinal bands, and
possesses the pleasant sweet odour of coumarin. There
is no distinct sap-wood. Hardness = Moderately soft.

Uses.—It is one of the most valuable brush timbers for
all purposes, being strong and tough. It is used for furni-
ture and cabinet work, motor body work, coach and carriage
building, railway-car construction, broom and other light
handles, turnery, brush-backs, broomstocks, machine-
framing, etc. It is rarely, if ever, attacked by the Powder
Post Borer, *Lyctus* sp.

Macroscopical characters.—Pores very small, almost indistinguishable with the naked eye. Soft tissue in irregularly spaced, reddish coloured, wavy, concentric lines, giving the wood its characteristic figure when tangentially cut. Rays fine, numerous, inconspicuous on end section. Growth rings indistinct.

Microscopical characters.—Pores evenly distributed, even sized, single or in short radial rows of 2–3 cells, rarely in small groups; radial diameter 20–80μ; mean 55μ; tangential diameter 30–75μ, mean 50μ; vessel segments 750–1,200μ in length; walls 2–3μ in thickness; lateral pitting usually scalariform in contact with rays or adjoining vessels; average number per sq. mm., 90; end perforation simple, rarely with cross bars in the specimens examined.[*] Wood fibres moderately thick walled; mean diameter 20μ; walls 3–4μ; length 1,200–2,000μ; pits bordered. Wood parenchyma in metatracheal bands 1–4 cells in width, to a lesser extent scattered or paratracheal. Rays heterogeneous, multiseriate rays up to 600μ in length, and 20μ in width; uniseriate rays 2–10 cells in height; 6–9 rays per mm. of transverse section.

Alcoholic extract pale yellow; practically no fluorescence on adding water, no turbidity; no evidence of flavone; very little alteration with ferric chloride.

Burns to greyish ash, practically no unburnt carbon.

<div style="text-align:center">

SCHIZOMERIA OVATA, D. Don.

Crab Apple, White Cherry, Whitewood, Humbug.

(Plate XI, Fig. 5.)

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A very large tree in the brushes of eastern New South Wales and Queensland, from Illawarra to north Queensland; a girth of twenty-seven feet has been measured.

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[*] This is not in accord with the statement in Solereder's "Systematic Anatomy of the Dicotyledous," English Translation, Vol. i., p. 317, Oxford 1908.
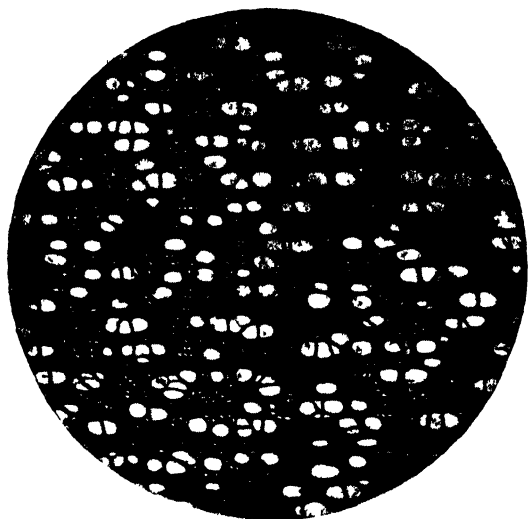
Fig. 5 —*Schizomeria ovata.*
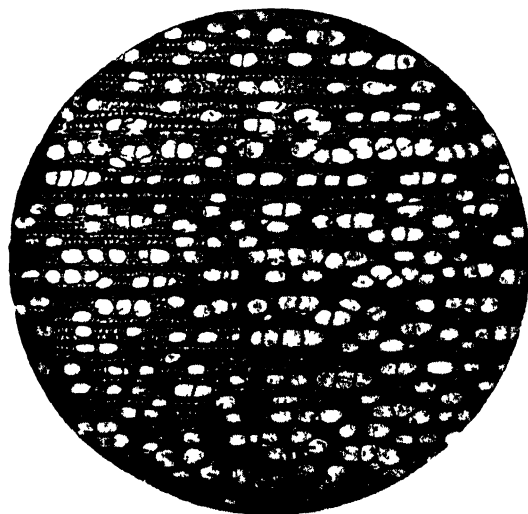
Fig 6.—*Ackama Muelleri.*

The wood is pale brown to pinkish brown in colour, close textured and of medium weight, about 37 lbs. per cubic foot. It is without distinctive figure, except for slightly darker longitudinal bands seen when the wood is cut tangentially. There is no distinct sap-wood. Hardness = Moderately soft.

Uses.—It would be suitable, if paraffined, for butter boxes, and it is often substituted as a "pine" timber. Suitable for case material, toys and small turned articles, etc. It is not recommended for use in cabinet work or joinery unless treated satisfactorily with creosote or other deterrent, as it is one of the brush timbers most liable to destruction by the Powder Post Borer. On no account should it be used in building construction.

Macroscopical characters.—Pores small, almost indistinguishable with the naked eye. Soft tissue in fine, irregularly spaced, wavy, concentric lines. Rays fine, numerous, slightly darker than rest of tissue when seen on a radial face. Growth rings not pronounced, but forming alternating dark and light coloured zones.

Microscopical characters.—Pores evenly distributed in short radial rows, rarely exceeding 5 cells, but occasionally as many as 8, often single, rarely in small, irregular groups; single pores elliptical; radial diameter 35–120μ, mean 75μ; tangential diameter 30–80μ, mean 55μ; vessel segments 350–800μ; walls 4–7μ; end perforation simple; lateral pits crowded, slit-like, borders elliptical or almost circular, simple, elliptical in contact with rays; average number per sq. mm., 50. Wood fibres moderately thick walled; average diameter, 40μ; 1,000–1,500μ in length; walls 4–7μ; thicker walled in denser part of growth ring; pits slit-like, very slightly bordered. Wood parenchyma fairly abundant, chiefly in irregular metatracheal bands up to 5 cells in width, to a lesser extent scattered or

paratracheal. Multiseriate rays, heterogeneous, numerous, up to 650μ in height, and rarely more than 2 cells in width; uniseriate rays 2–15 cells in height; cell walls not thickened or prominently pitted; 10–13 rays per mm. in transverse section.

Alcoholic extract almost water white, very slight fluorescence on adding water, no turbidity; no evidence of flavone; very little alteration with ferric chloride.

Does not burn to ash, practically all unburnt carbon.

ACKAMA MUELLERI, Benth.

Corkwood, Brown Alder, Sugar Bark, Pencil Cedar.

(Plate XI, Fig. 6)

A tree reaching a large size, up to 9 feet in girth or more in the brush forests of eastern New South Wales or Queensland, from Sydney to north Queensland.

The wood is pinkish brown to reddish brown in colour; weight about 38 lbs. per cubic foot; close textured, and without distinctive markings. There is no distinct sapwood. Hardness = Moderately soft.

Uses.—Suitable for joinery, floorings, moulding, carving, brush-stocks, ' boot-heels, etc. Requires careful seasoning.

Macroscopical characters.—Pores small, almost indistinguishable with the naked eye, crowded. Soft tissue not apparent. Rays fine, numerous, conspicuous on quarter cut sections. Growth rings indistinct.*

Microscopical characters.—Pores evenly distributed, even sized, single or in short radial rows of rarely more than 3

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* It can be separated readily from the principal other Corkwood, *Endiandra Sieberi,* Natural Order Laurineæ, by the numerous concentric lines of soft tissue which occur in the latter timber.

cells, or in small irregularly connected groups, single pores, irregularly elliptical in section; radial diameter 40–110μ, mean 75μ; tangential diameter 55–95μ, mean 70μ; vessel segments 225–900μ in length; walls 3–5μ; end perforation usually scalariform, 1–14 bars, rarely simple; lateral pits often scalariform in contact with rays; average number per sq. mm., 60. Wood fibres thick walled; average diameter 25μ; length 1,500–2,500μ; walls 5–7μ in thickness, lumen often reduced to 4μ; lateral pits narrow elliptical, slightly bordered. Wood parenchyma paratracheal or scattered, sometimes in short metatracheal bands, not more than 1 cell in width. Chambered crystal parenchyma cells present. Rays heterogeneous, vertical cells often considerably elongated and heavily pitted; multiseriate rays up to 1,500μ in height, 60μ in width; uniseriate rays 2–12 cells in height; rays per mm. in transverse section, 10–12.

Alcoholic extract orange brown; fluorescence very slight on adding water, no turbidity; deep brownish green with ferric chloride; no evidence of flavone.

Burns to greyish ash, little unburnt carbon.

ACKAMA QUADRIVALVIS.   C. T. White.
Brown Alder, Pencil Cedar.
(Plate XII., Fig. 7.)

A large forest tree found in the Atherton and Cooktown districts of north Queensland.

The wood is pinkish brown to reddish brown in colour; moderately close textured; of medium weight, about 39 lbs. per cubic foot; without distinctive markings. No distinct sap-wood. Hardness = Moderately soft.

Uses.—Similar to Corkwood, *Ackama Muelleri.*

*Macroscopical characters.**—Pores small but easily visible

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* The specimen examined was obtained from Atherton, through the Queensland Forest Service, but was without botanical material.

with the naked eye. Soft tissue not apparent. Rays fine, inconspicuous. Growth rings indistinct.

Microscopical characters.—Pores usually in pairs, radially distributed, sometimes single or in short rows of 2–3 cells; single pores elliptical; radial diameter 100–180μ, mean 135μ; tangential diameter 75–150μ, mean 110μ; length of segments 450–900μ; walls 4–5μ; end perforation simple; lateral pits crowded, borders circular or elliptical, simple in contact with rays; number per sq. mm., 8. Wood parenchyma not abundant, scattered or paratracheal; chambered crystal parenchyma present. Wood fibres moderately thick walled; mean diameter 20μ; length 1,350–2,100μ; walls 3–5μ; pits slit-like, scarcely bordered. Multiseriate rays heterogeneous, up to 1,000μ in height and 45μ in width; uniseriate rays often almost homogeneous, 2–12 cells in height; cell walls thick and prominently pitted; 10–13 per mm. of transverse section.

Alcoholic extract deep reddish brown; no fluorescence on adding water, no turbidity; deep brownish green with ferric chloride; no evidence of flavone.

Burns almost completely to very white ash, practically no unburnt carbon.

WEINMANNIA LACHNOCARPA, * F.v.M.

Mararie, Marara.

(Plate XII., Fig. 8.)

A large tree occurring in the brush parts of northern New South Wales and southern Queensland. The wood is pinkish to pinkish-brown in colour; very close textured; heavy, weight per cubic foot = 54 lbs.; without distinctive figure. There is no distinct sap-wood. Hardness = Hard.

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* *Geissois lachnocarpa*, J.H.M. in Maiden's "Forest Flora of New South Wales," Vol. 19.
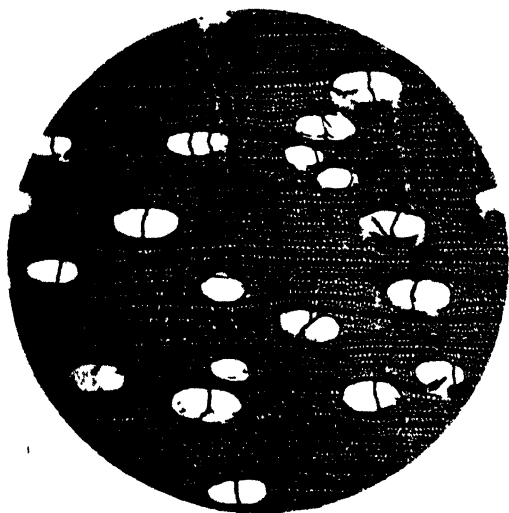
Fig 7.—*Ackama quadrivalvis*
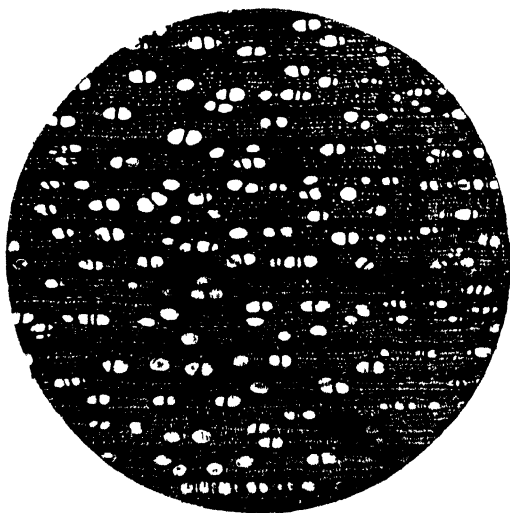
Fig. 8.— *Weinmannia lachnocarpa.*

Uses.—Has been used for heavy coach and carriage construction, general building and construction purposes, mallets, chisel-handles, wood working planes, heads of golf-clubs, machinery bearings, and for purposes where strength and hardness are required.†

Macroscopical characters.—Pores very small, not crowded, almost indistinguishable with the naked eye. Soft tissue not apparent. Rays fine, numerous, inconspicuous on end section, moderately conspicuous on a radial face. Growth rings very indistinct.

Microscopical characters.—Pores evenly distributed, single or in short radial rows of 2–5, rarely, however, exceeding 3; single pores usually elliptical; radial diameter 30–110μ, mean 80μ; tangential diameter 35–75μ, mean 60μ; vessel segments 450–800μ; walls 5–7μ; end perforation simple; lateral pits slit-like, border circular or elliptical, crowded; number per sq. mm., 45–60. Wood fibres thick walled, mean diameter 16μ; 1,050–1,650μ in length; walls 4–7μ; pits slit-like, scarcely bordered. Wood parenchyma abundant, paratracheal, scattered, or forming numerous irregular metatracheal bands 1 cell in width. Chambered crystal parenchyma present. Multiseriate rays heterogeneous, up to 600μ in height, and 45μ in width; uniseriate rays 2–14 cells in height, often almost homogeneous; cell walls strongly pitted, thick walled; average number per sq. mm. in transverse section, 7.

Alcoholic extract orange brown; very slight bluish fluorescence on adding water, no turbidity; no evidence of flavone; deep brownish green with ferric chloride.

Burns to fine brownish-grey ash, practically no unburnt carbon.

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† For physical tests see "Hardwoods of Australia," R. T. Baker, Sydney, 1919.

GEISSOIS BENTHAMI, F.v.M.

Red Carrabeen.

(Plate XIII, Fig. 9.)

A large tree found in the brush forests of northern New South Wales and southern Queensland.

The wood is pinkish to pinkish brown in colour; close textured, of moderate weight, 36–40 lbs. per cubic foot, and devoid of distinctive markings. There is no distinct sap-wood. Hardness == Moderately soft.

Uses.—General building purposes and joinery work, furniture and cabinet work, turnery, etc. It is available in moderately large quantities, and is often used as a substitute for Queensland Maple, *Flindersia Chatawaiana,* but is said to be rather more difficult to season than that wood.

Macroscopical characters.—Pores small, but visible with naked eye. Soft tissue scarcely apparent as indistinct lines in the denser portion of the growth rings. Rays fine, numerous, moderately conspicuous on a radial face. Growth rings moderately prominent, denser tissue marked by comparative absence of apparent pores.

Microscopical characters.—Pores fairly evenly distributed, in radial rows of 2–5, or in small irregularly connected groups, rarely single, single pores elliptical in section, very variable in size; radial diameter 35–200μ, mean 100μ; tangential diameter 35–110μ, mean 90μ; vessel segments 500–900μ in length; walls 6–8μ; end perforation simple in all material examined; lateral pits crowded, slit-like, borders circular or somewhat elliptical, pits large, elliptical, simple in contact with rays; average number per sq. mm., 30. Wood fibres moderately thick walled; mean diameter 20μ; walls 3–6μ; length 900–2,000μ; pits slightly bordered, slit-like. A zone of thicker walled fibres with

Fig. 9.—*Geissois Benthami.*

GEISSOIS BENTHAMI, F.v.M.
Red Carrabeen.
(Plate XIII, Fig. 9.)

A large tree found in the brush forests of northern New South Wales and southern Queensland.

The wood is pinkish to pinkish brown in colour; close textured; of moderate weight, 36–40 lbs. per cubic foot, and devoid of distinctive markings. There is no distinct sap-wood. Hardness = Moderately soft.

Uses.—General building purposes and joinery work, furniture and cabinet work, turnery, etc. It is available in moderately large quantities, and is often used as a substitute for Queensland Maple, *Flindersia Chatawaiana,* but is said to be rather more difficult to season than that wood.

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Fig. 9.—*Geissois Benthami.*

small lumen occurs in the denser part of the growth ring. Wood parenchyma not abundant, paratracheal or scattered, with a tendency to form metatracheal bands of 1 cell in width, particularly in the denser part of the growth ring. Chambered crystal parenchyma somewhat abundant. Rays heterogeneous, walls of vertical cells strongly pitted; multiseriate rays up to 750μ in height, 40μ in width; uniseriate rays sometimes almost homogeneous, 2–20 cells in height; rays per mm. in transverse section, 12–15.

Alcoholic extract pale yellow; very slight bluish fluorescence on adding water, no turbidity; very little alteration with ferric chloride; no evidence of flavone.

Burns to greyish ash, little unburnt carbon.

Key to the Timbers.

The following key is based on macroscopical characters:

(a)

Soft tissue easily visible on end sect on as numerous, fine, wavy concentric lines.

(b)

Pores in short radial rows 1–5 cells, growth rings distinct, soft tissue pale coloured, no odour.

Schizomeria ovata.

(b₁)

Pores usually single; growth rings indistinct; soft tissue reddish in colour; fragrant odour.

Ceratopetalum apetalum.

(a₁)

Soft tissue rings not apparent to naked eye (except as inconspicuous lines at junction of denser portion of growth ring in *Geissois*).

(c)

Pores in short radial rows, not crowded, easily visible with naked eye.

(d)

Pores in radial rows of 2–3, rarely more; growth rings indistinct.

(d_1)   *Ackama quadrivalvis.*

Pores in radial rows of 2–5 or more; growth rings moderately prominent.

(c_1)   *Geissois Benthami.*

Pores crowded, usually single or in small groups, scarcely visible with naked eye.

(e)

Rays prominent, larger ones conspicuous on end section.

(f)

Wood pale yellow, rays pale in colour.

(f_1)   *Polyosma Cunninghamii.*

Wood pinkish to reddish brown, rays reddish.

(e_1)   *Quintinia Sieberi.*

Rays inconspicuous on end grain.

(g)

Pores very numerous, wood moderately soft, pinkish brown to reddish brown in colour.

(g_1)   *Ackama Muelleri.*

Pores numerous; wood hard to moderately hard; pale to pinkish brown in colour.

(h)

Growth rings indistinct, wood heavy, rays not very conspicuous on radial face, very little darker than other wood.

(h_1)   *Weinmannia lachnocarpa.*

Growth rings somewhat prominent, especially on a tangential face; rays conspicuous on radial face, much darker than other wood.

Callicoma serratifolia.

Summary.—The woods described are without sharp differentiation of sap-wood and heart-wood. Growth rings are not sharply defined, but are most prominent in *Callicoma* and *Schizomeria*. Pores, which are diffuse, are often indistinguishable with the naked eye, are usually crowded, and number up to 125 per sq. mm., in *Callicoma*. Vessel segments with simple end perforation occur in *Ceratopetalum, Schizomeria, Weinmannia* and *Geissois,* and scalariform end perforation is found in *Quintinia, Polyosma* and *Callicoma*. Either or both types of perforation are present in *Ackama*. Tyloses were not observed.

Wood parenchyma occurs as prominent metatracheal bands of several cells in width in *Ceratopetalum* and *Schizomeria;* in numerous bands of not more than one cell in width in *Weinmannia;* in the other species it is principally either paratracheal or scattered. Chambered crystal parenchyma was observed in *Ackama, Weinmannia* and *Geissois*. Wood fibres reach an exceptional length in *Polyosma Cunninghamii,* measuring up to 3 mm.

Multiseriate rays occur in all species examined, but are not more than two cells in width in *Schizomeria;* a maximum width of 300μ is found in *Quintinia*. Uniseriate rays reach a maximum height in *Polyosma*. With the exception of *Schizomeria,* all the ray cells are more or less thick walled and prominently pitted.

Explanation of Plates.

Fig. 1.   Transverse section *Quintinia Sieberi,* A.DC. x 18.
Fig. 2.   „   „   *Polyosma Cunninghamii,*
                                       Benn. x 18.
Fig. 3.   „   „   *Callicoma serratifolia,*
                                       Andr. x 18.
Fig. 4.   „   „   *Ceratopetalum apetalum,*
                                       D.Don x 18.

Fig. 5.   „   „   *Schizomeria ovata,*
                                          D.Don. x 18.

Fig. 6.   „   „   *Ackama Muelleri,* Benth. x 18.

Fig. 7.   „   „   *Ackama quadrivalvis,*
                                          C.T.W. x 18.

Fig. 8.   „   „   *Weinmannia lachnocarpa,*
                                          F.v.M. x 18.

Fig. 9.   „   „   *Geissois Benthami,*
                                          F.v.M. x 18.

I wish to record my thanks to Messrs. D. Cannon and F. Shambler, of the Museum staff, for their assistance in many ways.

Technological Museum,
      Sydney.

THE USE OF PHOSPHORUS PENTACHLORIDE IN THE PREPARATION OF GLYCERIDES.

By R. K. NEWMAN, B.Sc., V. M. TRIKOJUS, B.Sc., and
G. HARKER, D.Sc., F.A.C.I.

In connection with an investigation on the hydrolysis of esters it was desired to prepare some tributyrin, but the yields obtained by the methods available in the literature were all disappointingly small. A new method was devised in which the sodium salt of the fatty acid was treated with phosphorus pentachloride and glycerol by means of which excellent yields of tributyrin and triisovalerin were obtained. Incidentally the boiling point of pure tributyrin was found to be 315.5° (corr.) a figure considerably higher than the one usually accepted, viz., 287°. At the conclusion of the work it was shown that a very good yield of tributyrin was obtainable by heating glycerol with excess of butyric acid, whilst distilling off the water formed during the course of the reaction. Although this is a simpler method than that using phosphorus pentachloride for the preparation of this particular glyceride, the latter method has a wider range of application for the preparation of esters generally, since the continuous removal of water by physical means is limited to those cases in which the reacting substances are less volatile than water. For example, the physical method could not be applied to the preparation of ethyl acetate by refluxing ethyl alcohol and acetic acid, but a satisfactory yield of the ester was obtained by the action of phosphorus pentachloride on the mixture of alcohol and sodium acetate.

Experimental.

The methods available in the literature were first tried and gave the following results:—

Dry hydrogen chloride was passed through a mixture of glycerol and butyric acid in the proportions 1 molecule of glycerol to 3 molecules of acid (Pelouze and Gelis, *Nouv.* Ann. de Chim. et de Phys., 1884, **10**, 455) and yielded tributyrin to the extent of about 40% of the theoretical quantity, which was reduced to 25% after purification by fractionation under reduced pressure. Difficulty was experienced in obtaining a halogen-free product, and it is probable that the low yield is due to the formation of chlorhydrins. On the other hand, only 15% of pure tributyrin was obtained when glycerol and butyric acid in the above proportions were boiled in a reflux apparatus for 60 hours (Lebedeff, Z., physiol. Chem., 1883, **6**, 150), and a similar yield resulted when the alcohol and acid in the same proportions were refluxed with concentrated sulphuric acid and with anhydrous zinc chloride for 3 hours. When a mixture of glycerol and butyric acid (1 mol. : 3 mols.) was heated under reduced pressure at 200° whilst a stream of dry air was sucked through it for 6 hours (Scheij, Rec. trav. chim., 1899, **18**, ·189), only a small yield of triglyceride was obtained.

Attempts were made to use the catalytic esterification method of Sabatier and Mahle (Compt. rend., 1911, **152**, 494), and mixtures of the vapours of glycerol and butyric acid were passed over titanium dioxide heated to 180°, but only traces of triglyceride were formed, although, with the same apparatus and catalyst, excellent yields of ethyl *iso*valerate resulted on passing a mixture of the vapours of ethyl alcohol and *iso*valeric acid.

Guth (Z. Biol., 1903, **44**, 96) prepared a number of glycerides by acting upon the chlorohydrins with the sodium salts of various acids. In this way mono- and di-glycerides were prepared and the triglycerides then formed from them. The production of triglycerides by this means is tedious, and it was felt that the action of phosphorus pentachloride upon a mixture of glycerol and the sodium salt of the fatty acid might well give a more direct method, which would eliminate the necessity for isolating intermediate compounds. Upon trial the method was found to give excellent results and to be simple in application.

In the first experiment, glycerol (1 mol.), sodium butyrate (3 mols.), and phosphorus pentachloride (1 mol.) were heated together under a reflux condenser, carrying a calcium chloride tube, for two hours in a metal bath kept at 200°. After cooling, the contents of the flask were washed with sodium carbonate solution, and extracted with ether. The ether was removed by distillation from the water bath, and the ester dried by warming it in vacuo whilst a stream of dry air was sucked through. The product thus extracted, of which there was a large yield, had a saponification value of 662.4, a chlorine content 13%, and a boiling point 264°. In the next experiments 5 mols. of sodium butyrate were employed, the temperature of the bath was raised to 235°, and the heating continued for six hours. Yields of triglyceride were obtained approximating 75% of the theoretical, with saponification values of 579-609 (calculated for tributyrin 557), and containing 1.9-5.8% chlorine. A product free from chlorine could not be obtained by fractional distillation under reduced pressure, but by refluxing with sodium butyrate for three hours and then distilling, the glyceride was obtained free from

chlorine and gave a saponification value of 555.6. In order to prepare the glyceride free from chlorine in one operation, 5½ mols. of sodium butyrate were employed and the heating continued for nine hours at 200°. In two parallel experiments the following results were obtained:—

Exp. 1. Yield. 93% Sap. val. 564. B.p. 312°-314° (corr. 763mm.).

Exp. 2. Yield. 93.4%' Sap. val. 566. B.p. 310°-311° (corr. 763mm.).

Both the samples were free from chlorine.

The product from experiment 2 was refractionated into two fractions:—

Fr. 1. 192-196/26mm. Sap. val. 573. B.p. 310° (corr. 763mm.).

Fr. 2. 196-200/26mm. Sap. val. 554. B.p. 315° (corr. 763mm.).

Fraction 2, the major fraction, was found to have a refractive index $n_D^{20°}$ 1.43585 and density $d_4^{20°}$ 1.0350.

The constants given for tributyrin in the sixth (1921) edition of Lewkowitsch are B.p. 287°-288° at normal pressure and 182°-184° at 24mm., refractive index $n_D^{20°}$ 1.48587, and density $d_4^{20°}$ 1.0324. The boiling point figures are evidently taken from Guth, reference to whose work has already been made, whilst the refractive index and density figures are derived from the paper by Scheij (loc. cit.); the refractive index figure given by Lewkowitsch is, however, a misprint for the 1.43587 in the original paper. 'With this correction the refractive index and density figures obtained agree closely with those given by Lewkowitsch, but there is a considerable discrepancy regarding the boiling point. Additional evidence of the
' purity of the tributyrin sample was afforded by a com-

bustion analysis, which gave the result :—(Found C, 59.4; H, 8.59 ; $C_{15}H_{26}O_6$ requires C, 59.5 ; H, 8.61%).

The synthesis of tri*iso*valerin was accomplished with equal success by the method, and a product obtained, after fractionation under reduced pressure, with a boiling point 209.5°-210.5°/27mm., 330.5°/763mm. (corr.) ; saponification value, 486 (calculated for tri*iso*valerin 489) ; refractive index $n_D^{20°}$ 1.43535 ; and density $d_{4°}^{20°}$ 0.9984. The sample was free from chlorine and a combustion analysis yielded the result :—(Found: C, 62.6; H, 9.16; $C_{18}H_{32}O_6$; requires C, 62.8; H, 9.3%). No figures could be obtained in the literature at our disposal for the physical ·constants of tri*iso*valerin.

It was thought of interest to try the method for the preparation of a simple ester such as ethyl acetate. Four mols. of sodium acetate, three mols. of ethyl alcohol, and ·one mol. of phosphorus pentachloride were mixed together in a flask cooled in ice and having attached to it a six-bulb reflux condenser through which a rapid stream of water at 4° was passed. When the initial vigorous reaction had subsided, the flask was heated on the water bath for one hour at 60°-70° and at 90°-100° for 2½ hours. The product was distilled from the water bath, and a 60% yield of ethyl acetate was obtained containing traces of acetyl chloride, which were readily removed by fractional distillation, leaving a product with a boiling point 75.5°-76.7° at 765mm. By this method of preparing ethyl acetate the substance is obtained dry and the difficulty of removing water from it is avoided.

Preparation of tributyrin from aγ-dibutyrin.—It was suggested by Prof. Kenner that the difference in the boiling points between the tributyrin prepared as above, and that obtained by Guth (loc. cit.) might be due to

the existence of two isomers in accordance with the views
of Grün (Ber., 1912, **45**, 3691), who has described two
isomeric trilaurins.   To test this point tributyrin was
prepared by Guth's method from $a\gamma$-dibutyrin.   On
heating some redistilled $a\gamma$-dichlorhydrin with a little more
than two molecules of sodium butyrate to 140°-150° for
six hours in a closed tube a 40% yield of $a\gamma$-dibutyrin
was obtained boiling at 173°-175°/20mm.   The product
contained a little chlorine and gave a saponification value
of 441 (calc. for dibutyrin 483).   It was apparent that
no advantage was gained by using a closed tube, and a
further quantity was prepared by heating the two reagents
in a Perkin flask in an oil bath kept at 160°-170°.   In
this case a 60% yield of chlorine free dibutyrin, b.p.
170°-176°/20mm., was obtained, giving a saponification
number of 460.5.   Forty grams of this substance were
subjected to fractional distillation under vacuum with
the object of purifying it, but it was clear from the
saponification values of the fractions and their boiling
points that decomposition was taking place, and an ap-
proximate boiling point only can be assigned to it.   Guth
collected at 173°-176°/19mm. and probably these limits
are nearest for a product with a good saponification
number.   The dibutyrin was next refluxed with excess of
butyric acid in accordance with Guth's instructions, but
a modification was introduced which has proved valuable
in the preparation of certain esters.   This consists in
continuously distilling off the water formed during the
refluxing of the alcohol and acid.   Eight grams of
dibutyrin with four times the theoretical amount of care-
fully redistilled butyric acid were placed in a Zeisel flask,
provided with a rod and disc column, and heated in a
metal bath so that the temperature at the side tube was
kept between 90°–100°.   The rod and disc apparatus was

inserted into the stem of the flask in order to aid in the separation of the water, and the heating was continued for 10 hours. On distilling the residue in the flask under vacuum very little unchanged dibutyrin came over, whilst the tributyrin was collected in two fractions as follows:—

Fr. I, 4.4 grams, 183°–186°/17mm. Sap. val. 562.

Fr. 2, 4.12 grams, 186°–188°/17mm. Sap. val. 557.

The combined fractions represented a yield of 82% of the theoretical.

The saponification values of both fractions were good, the second fraction giving the exact number for pure tributyrin. The boiling point of this fraction was found to be 315° under normal pressure, and was identical with the boiling point of the sample prepared by the phosphorus pentachloride method. The specimen prepared by Guth, b.p. 287°–288°, was, therefore, impure, and in all probability was contaminated with a considerable quantity of unchanged dibutyrin. In the experiment just described, where the water formed during the refluxing was continuously withdrawn, very little unchanged dibutyrin was left, and there was no trouble in separating it by fractional distillation.

Preparation of tributyrin from glycerol and butyric acid.—The ready conversion of dibutyrin into tributyrin by refluxing with butyric acid under the conditions mentioned at once raised the question as to whether tributyrin could not be prepared directly from glycerol and butyric acid in good yield by the same means. Six grams of glycerol were refluxed with 36 grams, i.e,, with about twice the theoretical amount, of butyric acid for 8-10 hours, keeping the temperature at the side tube of the flask between 90°–100°. On distillation two fractions were obtained:—

Fr. 1, 9.2 grams, 186–187/16mm. Sap. val. 557.2.

Fr. 2, 6.3 grams, 187–188/16mm. Sap. val. 555.3.

The first fraction with the better saponification value had a boiling point at 760 mm. of 315.5° (corr.), using a standardised (N.P.L.) thermometer. When freshly prepared it had a pleasant sweetish odour. The combined fractions represented a yield of 80% of the theoretical.

Of all the methods described in this paper, the highest yield of tributyrin was obtained when using phosphorus pentachloride.

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THE CONSTITUTION OF AUSTRALOL.

By J. C. EARL, B.Sc., Ph.D., and V. M. TRIKOJUS, B.Sc.

(Read before the Royal Society of New South Wales, Nov. 4, 1925.)

The occurrence of two hitherto undiscovered phenols in eucalyptus oils was recorded by Robinson and Smith (this Journal, 1914, **48**, 518). One of these, a well crystallised solid, was examined later in considerable detail by Smith and named by him, Australol (Research on the Eucalypts 2nd. Ed. p. 395). The other, Tasmanol, a liquid phenol which occurs principally in the oils of the Tasmanian eucalypts, was not investigated very closely.

At the time of his death, Mr. Smith was planning further work on these two substances, and, as a suitable source of the phenols, he had obtained a quantity of the residue from the commercial refining of the oil of *Eucalyptus polybractea,* a species which is distilled to a considerable extent, both in New South Wales and in Victoria. This material, which was used for the present investigation, was a dark-coloured oil of specific gravity 0.970 at 15°C. The absence of a notable quantity of aldehydes or ketones was indicated by the fact that, on treatment with a solution of sodium bisulphite, the oil underwent no appreciable diminution in volume. The saponification number was 50-51; after acetylation this was raised to 121, showing that hydroxy compounds were present in considerable amount. By direct absorption with potassium hydroxide solution, it was found that the oil contained 9 to 10 per cent. of phenols.

An exploratory fractional distillation of 250 grams of the oil at 27-27 mm. pressure was made, and the resulting fractions examined with a view to ascertaining whether a concentration of the phenols in any one or more fractions could be effected. The following results were obtained :—

Temperature.		Weight of fraction.		Phenols.
up to 126°C.	..	11.8 grams	..	11 per cent.
126° to 131°	..	24.0 „	..	10 „ „
131° to 140°	..	31.6 „	..	10 „ „
140° to 150°	..	35.4 „	..	9 „ „
150° to 160°	..	45.4 „	..	8 „ „
Residue and loss	..	102.0 „	..	

It would appear, therefore, that most of the phenols are ·contained in that part of the oil boiling below 160° at 25-27 mm. Hence, as a preliminary to the extraction of the phenols, the oil was distilled in batches of 350 c.c. at 27 mm. pressure, the fractions up to 160° and 160° to 186° being collected. The average weight of the first fraction from a number of such distillations was 217 grams.

For the extraction of the phenols, 650 c.c. of the fraction up to 160° were shaken with 1,400 c.c. of a 4 per cent. solution of sodium hydroxide. The alkaline solution, after separation from the oil and washing with ether, was rendered acid, and the liberated phenols extracted with ether.

Distillation of the phenols at 30 mm. pressure gave the following fractions :—

A. 135-140° .. ..   16 grams
B. 140-165° .. ..   5.2 grams
C. Above 165° .. ..   2 grams

Fraction A, when cooled and seeded with a fragment of solid australol, became partly crystalline. By filtration ·of the semi-solid mass at 0°, 6 grams of the crystalline phenol were obtained. Re-distillation of the filtrate and of the higher fractions yielded a further small quantity of the 'product. The melting point of the solid phenol was 60°,

and on benzoylation by the Schotten-Baumann method, it gave a well-crystallised solid benzoate, melting at 71.5°. Analysis of australol benzoate:—Found C, 79.7; H, 6.8 per cent; calculated for $C_{16}H_{16}O_2$; C, 79.9; H, 6.7 per cent.

The composition of australol as recorded by Smith was $C_9H_{12}O$, and confirmation of this is furnished by the anaylsis of the benzoate quoted above. The structure originally suggested for the compound, mainly on the grounds of its reaction with bromine and its molecular refraction, was that of a dihydro-p-allyl phenol. A closer examination of the reaction with bromine, however, showed it to be a process of substitution, not one of addition. The quantity of bromine required to produce a permanent colouration in a chloroform solution of the phenol was found to be approximately equivalent to one molecular proportion. At the same time, an amount of hydrogen bromide was evolved, corresponding to rather more than half of the bromine added. It is thus clearly indicated that a substitution reaction had taken place, in accordance with the equation:—

$$C_9H_{12}O + Br_2 = C_9H_{11}OBr + HBr.$$
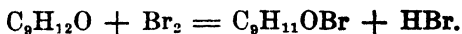
The constitution suggested by Smith for australol is thus invalidated, and a structure must be assigned to it more in accordance with its behaviour as a saturated compound. Reference to the literature regarding the known phenols of the composition $C_9H_{12}O$ revealed that the properties recorded for p-isopropyl phenol correspond closely with those of australol. Further, the benzoate of australol, and also the methyl ether prepared by methylating the phenol by means of methyl sulphate and sodium hydroxide, were apparently identical in properties with the corresponding derivatives of p-isopropyl phenol (Behal and Tiffeneau, Bull. Soc. chim. 1908 [4], 3, 318). The comparison is summarised in the following table:—

	Australol.	p-Isopropyl. phenol.
Melting point of phenol	60° *	59-60°
Melting point of benzoate	71.5°	70-71°
Boiling point of methyl ether	211-212°	210-212°

To enable the identity of the two phenols to be definitely established, p-isopropyl phenol was prepared synthetically by published methods, which are briefly outlined below. Magnesium phenyl bromide was condensed with acetone, and the compound so formed, on decomposition with water, yielded phenyl dimethyl carbinol (Tiffeneau, Ann. Chim. Phys. 1907, [8], 10, 155). This was then dehydrated by heating with potassium bisulphate to give the unsaturated hydrocarbon, phenyl isopropenyl benzene. (Perkin and Matsubara, J.C.S. 1905, 87, 672.) This method for the production of phenyl isopropenyl benzene was found to be more expeditious than the procedure of heating the product of the reaction between acetone and phenyl magnesium bromide with an excess of the latter substance, as recommended by Tiffeneau (loc. cit.). The phenyl isopropenyl benzene was reduced to cumene or isopropyl benzene by means of sodium and alcohol (Klages, Ber. 1902, 35, 3507).

The sulphonation of cumene was readily effected by treating it with cold, slightly fuming sulphuric acid (Claus and Tonn, Ber. 1885, 18, 1239). The o- and p-sulphonic acids so formed were separated by crystallisation of their barium salts, that of the p-acid being much the less soluble in water. From 50 grams of cumene 62 grams of barium p-isopropyl benzene sulphonate were obtained. Without further purification, this was converted into the correspond-

* The melting points recorded in this paper for both the natural and synthetic phenols, were those found for the freshly crystallised material. For samples which had been kept for several months, melting points as high as 63° were observed. (cf. Penfold, This Journal, 1923, 57, 88.)

ing potassium salt, which was then fused with twice its weight of potassium hydroxide at 250° for three-quarters of an hour. After solution of the melt in water, acid was added and the phenol obtained in a slightly impure condition by steam distillation. The most effective method of purification was found to be conversion into the benzoate (m.p. 71-72°), by means of benzoyl chloride in the presence of sodium hydroxide, and decomposition of this by hydrolysis with alcoholic potash, the phenol being precipitated from the diluted alkaline solution by carbon dioxide. So obtained it had a melting point of 60°.

The melting points of a mixture of the synthetic phenol and australol, and of a mixture of the two benzoates, were determined, but in neither case was any depression observed. The identity of australol with p-isopropyl phenol is, therefore, fully established.

Although, as has been shown, p-isopropyl phenol is the principal phenol in the oil of *Eucalyptus polybractea,* there are present also other phenols of higher boiling point. Among these is the liquid phenol, tasmanol, which is characterised by the production of a crimson colour with ferric chloride in alcoholic solution. The higher fractions, however, did not yield a solid benzoate, so that the method adopted for the isolation of australol is not applicable in this case. The investigation has not yet been carried further, but it is hoped to make it the subject of future work.

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THE ESSENTIAL OILS OF *MELALEUCA LINARII-FOLIA* (SMITH), AND *M. ALTERNIFOLIA* (CHEEL).

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(*Read before the Royal Society of New South Wales, Nov. 4, 1925.*)

MELALEUCA LINARIIFOLIA (SMITH).
(With Plate XIV.)

The botany of this tall and somewhat attractive "Tea Tree," which occurs very abundantly in the coast districts of New South Wales and Southern Queensland, is very fully described in "Flora Australiensis," Vol. 3, 140. It possesses a papery bark, and not only attains to a good height, but, in a luxuriant condition, spreads very widely at the top, forming a splendid shade tree, as may be seen from the photographs at the end of this paper. It follows the water courses and flourishes in all swampy situations. It has since been referred to by E. Cheel in the Journal & Proceedings of this Society, Vol. LVI (1922), pp. 78-81. The essential oil, as well as the histological characters of its leaves, have previously been dealt with by Baker and Smith in their series of papers on "The Australian Melaleucas and Their Essential Oils," Part 1 (this Journal, Vol. XL (1906), pp. 65-69. A number of enquiries which were made regarding the economic utilisation of this essential oil necessitated a reference to the paper referred to, but unfortunately the published information regarding its chemical composition was found to be of no value. Beyond the statement that the crude oil was largely a terpene one containing 16 per cent. of
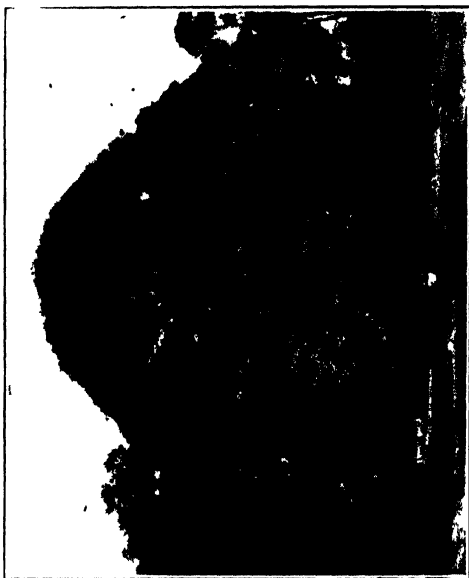
Trees of *Melaleuca linariifolia* growing at the 62 mile peg (from Sydney), on the Great Southern Road, N.S.W.

cineol, no data are given as to what constituted the remaining 84 per cent. Therefore, I was reluctantly compelled to re-investigate the essential oil, but the extremely interesting results obtained proved it to be well worth the trouble.

Accordingly, leaves and terminal branchlets were procured from Cabramatta and Peakhurst, two districts within 20 miles of Sydney.

The Essential Oil.

The essential oils were of a pale lemon colour, with a pleasant terpenic and myristic odour, the latter being most pronounced when the fresh leaves of the tree were crushed between the fingers. Altogether, 582½ lbs. of leaves and terminal branchlets, cut as for commercial purposes, were subjected to steam distillation, the average yield of oil being 1.5%. A distillation made of "sucker" growth yielded 2.05% of oil. The principal constituents, which have so far been identified, were found to be α and γ terpinene, cymene (these bodies constituted the principal terpenic compound), sabinene ?, cineol (about 16-20%), Δ^1-terpinenol-4, sesquiterpenes (the principal one of which was cadinene) with corresponding sesquiterpene alcohol. So far as the author is aware this is the first record of the occurrence of γ-terpinene and Δ^1-terpinenol-4 in an Australian essential oil. The determination of the alcohol is of special interest, more particularly as it occurs in such an oil as that of nutmeg, which tends to show that it has some connection with the myristic odour.

Experimental.

From the places mentioned 582½lbs. weight of leaves and terminal branchlets yielded, on distillation with steam, crude oils, possessing the chemical and physical characters, as shown in table:—

Date.	Locality.	Weight of leaves.	Yield of oil.	Specific gravity $\frac{15}{15°}$C	Optical rotation.
15/8/1922	Cabramatta, near Sydney.	128 lbs.	1·34%	0·8927	+ 5.2°
30/1/1923	do.	33 lbs.	2·05%	0·8978	+ 6.8°
4/5/1923	Peakhurst, do.	421½ lbs.	1·59%	0·8992	+ 3.3°

Refractive index 20° C.	Solubility.	Ester No. 1½ hrs. hot. sap.	Ester No. 1½ hrs. hot. sap. after acetylation.	Remarks.
1.4780	insol. 10-vols. 70% alcohol sol. 0·8-vol., 80%	1·3	68·5	adult leaves.
1·4760	sol. 10-vols 70% alcohol	1·8	82·10	"sucker" growth.
1·4752	insol. 10-vols. 70% alcohol sol. 0·8-vol. 80%	2·67	58·23	adult leaves.

On distillation, the crude oils behaved as follows:—

15/8/1922.—950 c.c. at 765 mm.:—20% at 170-180°, 28% at 180-190°, 18% at 190-205°, 8% at 205-215°, and 26% residue.

4/5/1923.—2500 c.c. at 765 mm.:—24% at 160-172°, 18% at 172-176°, 13% at 176-180°, 11% at 180-186°, 3% at 186-190°, 2% at 190-195°, 8% between 195-203°, and 20% above 203°.

Determination of Terpenes.—The fractions of oils boiling below 190° from both the above consignments were treated with 50% resorcin solution until the greater portion of the cineol had been removed (this procedure was very laborious, as in the treatment of the second lot of oil over-

400 c.c. of cineol had to be removed). They were then repeatedly fractionated at 765 mm. and 20 mm. until the following fractions were separated for examination:—

Boiling Point.		Quantity.	Specific 15° Gravity 15°.	Optical Rotation.	Refractive Index 20°
15th August, 1922.					
63-65°	at 20 mm.	5 c.c.	0.8454	inactive	1.4656
65-70°	20 mm.	15 c.c.	0.8507	+0.75°	1.4684
70-72°	20 mm.	43 c.c.	0.8534	+1.5°	1.4722
72½-75°	20 mm.	65 c.c.	0.8562	+1.75°	1.4755
75½-78°	20 mm.	122 c.c.	0.8589	+1.75°	1.4769
4th May, 1923.					
161-165°	at 763 mm.	56 c.c.	0.8470	—3.25°	1.4661
165-170°	763 mm.	50 c.c.	0.8478	+0.75°	1.4688
170-175°	763 mm.	122 c.c.	0.8514	+1.8°	1.4730
176-180°	763 mm.	426 c.c.	0.8566	+2.25°	1.4743

Pinene.—A very small quantity of liquid, about 4 c.c. of boiling point 156-160° at 768 mm., was isolated from one of the low boiling fractions (15/8/1922 lot), and although it possessed a specific gravity $\frac{15°}{15°}$ of 0.8501, optical rotation —1.2°, and refractive index, 20° 1.4642, it readily yielded a small quantity of nitrosochloride which on purification melted at 86-87°. Although the melting point was much under that usually found for pinene (109°), yet it was observed several years later when similarly examining the oil of *Melaleuca alternifolia* (see p. 320) that the melting point could be raised to 109° if sufficient was available for repeated purification.

The foregoing data, coupled with the fact that pinene has been definitely proved to be present in the oil of *Melaleuca alternifolia,* are convincing evidence to the author that pinene is an actual constituent of this oil.

Sabinene?—Fraction, 63-65° at 20 mm. (15/8/1922) on treatment with dry hydrochloric acid in dry ether solution gave an excellent yield of dihydrochloride which on recrystallisation from ethyl alcohol melted at 52°.

Fraction, 161-165° at 763 mm. (4/5/23) possessed all the general physical characters for sabinene and although it yielded a dihydrochloride of melting point 52° yet on oxidation by the method of Wallach (Liebig's Annalen 1908, **359**, 266) it failed to give any sabinenic acid. Its identity remains unproven for the present.

a and γ Terpinene.—The fractions of boiling point 72½-75° and 75½-78° at 20 mm. (15/8/22) and also that of 176-180° at 763 mm. (426 c.c., 4/5/23) appeared to represent a distinct terpene inasmuch as they failed to yield either a nitrosochloride, bromide or nitrosite, but gave a good yield of dihydrochloride of melting point 53-54°, when treated with dry hydrochloric acid in dry ether solution.   Oxidation, however, by the method of Wallach, fully described in Gildemeister & Hoffmann's "The Volatile Oils," Vol. 1, p. 321, resulted in its resolution into a mixture of *a* and γ terpinene and cymene.

One hundred and two c.c. of terpene, fraction 176-180° at 763 mm., 420 grams potassium permanganate, 168 grams potassium hydroxide, 4800 grams ice and 4800 c.c. water were shaken on a shaking machine.   When the reaction appeared to be completed the mixture was subjected to steam distillation and the unchanged terpene, about 20 c.c., removed (see under cymene).   The manganese oxide was separated by filtration, and the filtrate evaporated to dryness in the presence of carbon dioxide.   The residue was extracted with alcohol, the alcoholic extract evaporated to dryness, and this latter residue recrystallised from hot water.   The crystals which separated were dried on a porous plate and recrystallised from 25% alcohol, when a good yield of erythritol $C_{10}H_{16}(OH)_4$, melting point 237-238° resulted.   The mother liquor from the erythritol was decomposed with dilute sulphuric acid and extracted with ethyl acetate. On removal of the solvent a mass of

crystals remained, which after pressing on a porous plate and recrystallising a number of times from ethyl acetate, melted at 189-190°. The crystals, therefore, were a, a^1, dihydroxy-a-methyl-a^1-isopropyladipic acid $C_{10}H_{18}O_6$. The identity of the foregoing acid and the erythritol was confirmed by molecular weight and combustion results. Their isolation and identification is conclusive evidence of the presence of a and γ terpinene. It will be observed that although a terpinene was shown to be present yet no nitrosite could be prepared, which body is a characteristic derivative. That it was not obtained in this instance is not unusual, as Messrs. Schimmel & Co. of Leipzig have on many occasions in their Semi-annual Reports directed attention to the fact that this derivative was not obtained when a terpinene was present in admixture with γ terpinene and cymene.

Cymene.—The 20 c.c. of unchanged terpene resulting from the oxidation of 102 c.c. of terpene (see above) was again treated with alkaline potassium permanganate solution at 0°, and the unoxidised terpene blown off from the reaction mixture by means of steam. In this way 11 c.c. of a water-white liquid were obtained possessing the following characters:—Boiling point 175-177° at 763 mm., specific gravity $\frac{15°}{15°}$ 0.8633, optically inactive, and refractive index, 20°, 1.4882. On oxidising the hydrocarbon by means of hot potassium permanganate (12 grams in 330 c.c. water) according to the method of Wallach (Leibig's Annalen, 1891, **264**, 10), an excellent yield of p-hydroxyisopropylbenzoic acid resulted. On recrystallisation from ethyl alcohol the crystals melted at 156-157° (large crystals melted at 157-158°). The presence of p-cymene was thus confirmed.

Both the lower and higher boiling fractions, even up to 186°, were found on examination to consist of mixtures

of α and γ terpinene and cymene, with a small quantity of cineol, in variable proportions.

It seems remarkable that α and γ terpinene and cymene should form a constant boiling mixture and behave to all intents and purposes as a separate terpene.

It is worthy of note that in a paper read before this Society on 7th September, 1923 (see Journal and Proceedings, Vol. LVII., p. 243), entitled "The Essential Oil of *Darwinia grandiflora* and the Presence of a New Acetic Acid Ester," attention was directed to a fraction of boiling point 174-177° at 763 mm. having a specific gravity $\frac{15°}{15°}$ 0.8513, optical rotation +2.45°, and refractive index 20° 1.4770. It yielded no other derivatives than a dihydrochloride melting at 53-54°.   In view of the foregoing results it was deemed worth while examining the remainder of this fraction to ascertain if its composition was similar to that described herein.   It was, therefore, oxidised in the manner described, and an examination of the resulting products showed it to consist of a mixture of α and γ terpinene and cymene.

Determination of Cineol.—Over 400 c.c. crude cineol were regenerated from the resorcin washings from the terpenes obtained from 2500 c.c. crude oil, 4/5/23.   It was found, however, to be somewhat impure, and although regenerated several times through the phosphoric acid compound the melting point was found to be low, the former being only —0.4°.   It was thought that possibly 1.4 cineol might be present, but its identity could not be established.   On passing dry HCl gas through the cineol in both acetic and ether solutions only dipentine hydrochloride could be separated, although its melting point was 50-51°.   On admixture with terpinene dihydrochloride the melting point of the mixture was about 40°.

It was possible, however, to freeze out a portion of ordinary cineol in a fair condition of purity.   It possessed the following characters:—Boiling point 176-177° at 767 mm., melting point +0.5° specific gravity $\frac{15°}{15°}$ 0.9281, optically inactive, refractive index 20° 1.4579.   The iodol compound melted at 112-113°.

Determination of Δ'-*Terptnenol-4.*—The higher boiling portion of both samples of oils, i.e., that distilling above 190°, were first washed with 8% caustic soda solution to remove traces of phenols, etc., and then repeatedly distilled at 10 mm. until the following final fractions were obtained:

ex Sample, 15/8/1922.				
Boiling point.	Quantity.	Specific gravity $\frac{15}{15}$°.	Optical rotation.	Refractive index, 20°.
93-96° at 10 mm.	39 c.c.	0·9844	+ 17·1	1·4793
96-98° do	50 c c.	0·9871	+ 16·75	1·4798
99-102° do.	22 c.c.	0·9874	+ 13 60	1·4820
ex Sample, 4/5/1923.				
93-96° at 10 mm.	180 c.c	0·9347	+ 14·2	1·4796

All four fractions failed to yield a phenylurethane when tested with phenylisocyanate, and did not solidify when cooled for some time at —20°.

Nitrosochloride.—On testing in the usual manner for this derivative all four fractions yielded small quantities, which on purification melted at 113° in some cases and at 115-116° in others.   The writer was inclined to interpret these results as showing the alcohol to be contaminated with some *a*-terpineol, but this reasoning failed to hold good when it was found that an authentic specimen of

terpinenol-4 kindly furnished by Messrs. Schimmel & Co., of Miltitz, near Leipzig, yielded a nitrosochloride melting· at 115-116°.

Napthylurethane.—The alcohol was found to react very readily with napthylisocyanate, and when equal volumes of the reagent and the alcohol fractions were brought into contact, combination was complete in the course of a few days. The derivative was obtained in beautiful needle-shaped crystals from dilute methyl alcohol solution that melted at 104-105°. A specimen of the corresponding *a*-terpineol derivative (ex *E. Australiana* oil) which had been prepared alongside for purposes of comparison melted at 144-146°.

Through the kindness of Messrs. Schimmel & Co., we were able to compare the alcohol and its derivatives with an authentic sample from another source. The sample thus presented had the following characters:—Boiling point $92\frac{1}{2}$-94° at 10 mm., specific gravity $\frac{15°}{15°}$ 0.9367, optical rotation +23.8°, and refractive index ($16\frac{1}{2}$°) 1.4792. The napthylurethane prepared in a similar manner, as described, and purified from dilute methyl alcohol solution, melted at 104-105°. No depression of melting point was observed with a mixture of the napthylurethanes from both samples of alcohols.

It seems worthy of mention that no record could be found in the literature regarding either the nitroso-chloride or the napthylurethane of terpinenol-4. The latter apparently is a most excellent derivative for the identification of this alcohol, and although Messrs. Schimmel & Co. were the first to use and recommend the use of napthylisocyanate for identifying alcohols in essential oils, they do not appear to have described the 'above mentioned derivative.

Glycol (Oxidation to 1-2-4 trioxyterpane).—Fifty c.c. of the alcohol fraction, 4/5/1923, were mixed with 18 grams potassium permanganate, 1800 grams water and 1000 grams ice, and placed on a shaking machine for about 30 minutes, when the reaction was completed. The reaction mixture was steam distilled and the manganese oxide removed by filtration. The filtrate was evaporated to dryness in a current of carbon dioxide and the glycol in good yield extracted from the residue with ethyl alcohol. On repeated purification from a mixture of chloroform and ether, in which it was sparingly soluble in the cold but dissolved on heating to boiling, it was obtained in white rosettes melting at 113-115°:—0.6176 gram in 10 c.c. absolute ethyl alcohol gave a reading of $+ 1.42°$, $[a]_D^{20°} = + 23°$.

The identity of the alcohol as Δ'-Terpinenol-4 has been definitely determined.

Determination of Sesquiterpenes.—The higher boiling portion of the crude oil ex 2500 c.c. lot, after removal of the alcoholic fraction, was repeatedly distilled at 10 mm., when the following distillates were obtained:—

No.	Boiling point 10 mm.	Quantity.	Specific gravity, $\frac{15°}{15°}$	Optical rotation.	Refractive index 20°
1	Below 100	48 c c.	0 9319	$+ 12°$	1·4822
2	„ 120	38 c c.	0 9303	$+ 12·25°$	1·4893
3	120-129	55 c c.	0·9278	$+ 16 5°$	1·5013
4	130-134	53 c.c.	0 9254	$+ 20 4°$	1 5055
5	135-138	82 c c.	0 9267	$+ 23·0°$	1·5073
6	138-160	25 c.c.	0·9474	too dark	1·5074

Fractions Nos. 3 to 5 were repeatedly redistilled over metallic sodium at 10 mm., when the following fractions were obtained:—

Nos.	Boiling point 10 mm.	Quantity	Specific gravity $\frac{15}{15}°$	Optical rotation.	Refractive index 20°
1	Below 121	12½ c.c.	0·9279	+ 11·5°	1·4898
2	121-129½	23 c.c.	0·9286	+ 14·55°	1·4992
3	130-134	85 c.c.	0·9243	+ 21 75°	1·5055
4	134½-137	59 c c.	0·9291	+ 24 1°	1·5074

Fractions Nos. 2 to 4 inclusive were apparently mixtures of sesquiterpenes, as they yielded in each case excellent amounts of hydrochlorides when treated with dry HCl gas in dry ether solution. Recrystallised from absolute alcohol, the crystals of dihydrochlorides melted at 118.5-119°:—0.2170 gram in 10 c.c. chloroform gave a reading of —0.8° $[a]_D^{17°}$ = —36.87°.

The fractions also gave the usual colour reactions with bromine vapour in acetic acid solution and with sulphuric acid in acetic anhydride. The foregoing evidence points to one of the sesquiterpenes being cadinene or one yielding cadinene dihydrochloride.

Determination of Sesquiterpene Alcohol.—The greenish coloured viscous fraction of boiling point 138-160° at 10 mm. (No. 6 sesquiterpene table, p.   ), left over after removal of sesquiterpenes, was again distilled at 10 mm., when the following main distillate was obtained:— Boiling point 146-160° at 10 mm., specific gravity $\frac{15°}{15°}$ 0.9474, too dark for optical rotation, and refractive index 20° 1.5074. It was treated with twice its volume of 90% formic acid on a boiling water-bath, when water was readily removed. The sesquiterpene thus liberated was separated and distilled several times over metallic sodium. The bright pale yellow coloured liquid possessed the

following characters:—Boiling point 134-137° at 10 mm., specific gravity 15/15° 0.9223, optical rotation +12, refractive index 20° 1.5100.

It gave the usual colour reactions mentioned above for sesquiterpenes, as well as an excellent yield of dihydrochloride of melting point 118.5°:—0.2986 gram of dihydrochloride in 10 c.c. chloroform gave a reading of —1.1°, $[a]_D^{17°} = -36.85°$.

The sesquiterpene alcohol, therefore, appears to correspond to the principal sesquiterpene resembling cadinene.

Determination of Phenolic Body.—The portion of oil distilling above 203° at 765 mm. ex 2500 c.c. lot, which had been washed with 8% sodium hydroxide solution, was repeatedly treated with ether to remove traces of dissolved oil. The alkaline liquor was treated with dilute sulphuric acid, and the liberated phenol and free acid taken up in ether, from which the latter was removed by means of sodium bicarbonate solution. About 1 gram of crude phenol was obtained from the ethereal solution. It had a refractive index of 1.5050° at 20°, and gave a dirty brown colouration with ferric chloride in alcoholic solution. It closely resembled in odour and general characters a phenol of the tasmanol-leptospermol series.

In conclusion, my thanks are due to the following:— Messrs. Schimmel & Co., of Miltitz, for kindly furnishing the authentic sample of Terpinenol-4; Mr. F. R. Morrison, A.S.T.C., A.A.C.I., Assistant Economic Chemist, for much assistance in the investigations; and Mr. F. O'Donnell, Laboratory Assistant, for the preliminary fractional distillations of the crude oils and for the laborious work of extracting the comparatively large quantity of cineol by means of resorcin solution from the numerous terpene fractions.

MELALEUCA ALTERNIFOLIA (CHEEL).

This tree, whilst bearing a superficial resemblance to *M. linariifolia*, is undoubtedly distinct, although it possesses an identical habitat. It is quite common in the North Coast district of New South Wales, being especially abundant at Copmanhurst (20 miles from Grafton), on the Clarence River. It was formerly classified as a variety of *M. linariifolia*, but has recently been raised to specific rank by E. Cheel (see this Journal, Vol. LVIII. (1924), pp. 189/197). The writer made a careful field inspection of this tree in May, 1924, and is able to confirm Mr. Cheel's contention that it is quite distinct and worthy of specific rank. Curiously enough, the essential oil is practically identical with that from *M. linariifolia*.

The Essential Oil.

The essential oils from two consignments were of a pale lemon tint with a pleasant terpenic and myristic odour. Altogether 644lbs. weight of leaves and terminal branchlets, cut as for commercial purposes, were procured from Copmanhurst through the courtesy of Mr. H. R. Lyons, Forest Guard at Grafton, and on distillation yielded 1.8% of oil. The principal constituents, which have so far been identified, were found to be *d-a*-pinene, *a* and γ terpinene, cymene (these bodies constituted the principal "terpene"), cineol (about 6-8%), Δ'-Terpinenol-4, sesquiterpenes (the principal one of which was cadinene), with corresponding sesquiterpene alcohol.

Experimental.

From Copmanhurst 644lbs. weight of leaves and branchlets yielded on distillation with steam, crude oils, possessing the chemical and physical characters, as shown in table :—

Date.	Locality.	Weight of leaves.	Yield of oil	Specific gravity $\frac{15}{15}°$	Optical rotation.
22/8/1924	Copmanhurst, N.S.W.	520 lbs.	1 83%	0·8961	+ 7·4°
19/2/1925	ditto.	124 lbs.	1·76%	0·8958	+ 6·8°

Refractive index 20°.	Solubility.	Ester No 1½ hours hot sap	Ester No. hot. sap. after acetylation.
1·4782	insoluble in 10 vols. 70%. soluble in 0 8 vol. 80% alcohol.	3 67	79·86
1·4790	ditto.	7 35	83 64

On distillation, the crude oils behaved as follows:—

22/8/1924.—2500 c.c. at 770 mm.:—42% at 160-180°, 18% at 180-190°, 18% at 190-205°, and 22% residue.

19/2/1925.—400 c.c. at 20-10 mm. ·—2% at 65-73° (20 mm.), 40% at 73-90° (20 mm.), 36% at 80-99° (10 mm.), 13% at 100-128° (10 mm.), and 9% residue.

Determination of Terpenes.—The fractions of oil boiling below 190° from consignment, 22/8/1924, were treated several times with 50% resorcin solution until the cineol had been removed. They were then repeatedly fractionated over metallic sodium at 768 mm. until the following fractions were separated for examination:—

No.	Boiling point	Quantity.	Specific gravity $\frac{15}{15}°$	Optical rotation.	Refractive index 20°.
1	157-161	7 c.c.	0 8528	+ 13·00°	1·4659
2	161-165	29 c.c.	0 8512	+ 11·2°	1·4682
3	165-170	68 c c.	0·8506	+ 7·2°	1·4720
4	170-175	64 c.c.	0 8503	+ 4·8°	1·4742
5	175-180	495 c c.	0·8511	+ 2·25°	1·4765
6	180-185	234 c c	0·8551	+ 2·8°	1·4757
7	185-190	270 c c	0 8519	+ 5·2°	1·4771

d-a-pinene.—Fraction 157-161° on treatment with amyl nitrite and acetic-hydrochloric acid at —20° readily yielded a nitrosochloride which on recrystallisation melted at 91° (see under *M. linariifolia,* p. 309). On repeated recrystallisation from methyl alcohol and chloroform the melting point was finally raised to 109°. In order to confirm the presence of pinene the nitrosochloride was treated with benzylamine in ethyl alcohol solution, and the nitrobenzylamine separated and purified. It melted at 122-123°. The presence of pinene was, therefore, definitely proved. The lower boiling terpene fractions possessing a dextro-rotation contained variable quantities of this terpene.

Fractions 161-165° and 165-170°.—These fractions on oxidation by the method described under *M. linariifolia,* p. 310, were found to consist essentially of a and γ terpinene with cymene and a little cineol.

Fraction 176-180°, 495 c.c.—This fraction, the largest of the terpenes, was oxidised according to the procedure described on page 310, using 85 c.c. of the terpene fraction, 350 grams potassium permanganate, 140 grams caustic potash, 4000 grams ice and 4000 c.c. water. The crystals of erythritol which were separated and purified melted at 238-239°. The mother liquor from the erythritol was decomposed and the liberated acid extracted with ethyl acetate and purified from the same solvent. The crystals of a, a¹ dihydroxy-a-methyl-a-isopropyladipic acid thus obtained melted at 188-189°. a and γ terpinene were thus identified as the main constituents of this terpene fraction.

Cymene.—From the foregoing oxidation 21 c.c. unchanged terpene were obtained by steam distillation of the reaction mixture. This was again treated with the

alkaline potassium permanganate solution at 0°, and the unoxidised terpene blown off by means of steam. In this way 9 c.c. of a water-white liquid was obtained, which on distillation over metallic sodium at 768 mm. gave the following:—Boiling point 175-177°, specific gravity $\frac{15°}{15°}$ 0.8698, optically inactive, refractive index 20° 1.4875. On oxidising the hydrocarbon by means of hot potassium permanganate, an excellent yield of p-hydroxyisopropyl-benzoic acid resulted, which on recrystallisation from ethyl alcohol melted at 156-157°.

Preparation of hydrochloride ex fraction 176-180°.— 12.5 c.c. of terpene were dissolved in 30 c.c. dry ether and the mixture saturated with dry HCl gas at —20°. On removal of the solvent the whole crystallised. The crystals were separated and dried on a porous plate. On crystallisation from alcohol they melted at 53-54°.

*Fraction 180-186°, 234 c.c.—*On redistillation this fraction yielded 135 c.c., distilling at 179-181° at 765 mm., possessing the following constants:—Specific gravity $\frac{15°}{15°}$ 0.8606, optical rotation +2.2°, and refractive index 20° 1.4759. The dihydrochloride prepared as described above melted at 53°-53.5°; 45 c.c. oxidised with alkaline potassium permanganate as described above was found to contain 32.5 c.c. a and γ terpinene, 6.5 c.c. cineol and 6 c.c. cymene.

*Determination of Cineol.—*Over 150 c.c. crude cineol were removed from the terpene fractions by means of 50% resorcin solution; this is equivalent to about 6-8%. After liberation from the resorcin solution by steam distillation it was twice regenerated through the phosphoric acid compound and distilled over metallic sodium at 768 mm., when the colourless liquid thus obtained possessed the following characters:—Boiling point 175-177° melting point —0.4°, specific gravity $\frac{15°}{15°}$

0.9252, optical rotation +0.15°, and refractive index 20°
1.4590.   Here again it was considered that possibly some
1-4 cineol might be present to account for the low specific
gravity and melting point, but the hydrochloride prepared
by passing dry HCl gas into both the acetic acid and dry
ethereal solutions yielded dipentine dihydrochloride,
melting point 50-51°.

Determination of Δ'-Terpinenol-4.—Repeated fractional
distillation at 10 mm. of that portion of the oil boiling above
190° at 768 mm. (after first washing with 8% sodium
hydroxide solution) resulted in the following fractions:—

	1.	2.
Quantity	196 cc.	52 c.c.
Boiling point, 10 mm.	93-96°	97-102°
Specific gravity $_{15°}^{15°}$	0.9371	0.9363
Optical rotation	+17.55°	+16.3°
Refractive Index 20°	1.4781	1.4806

Both fractions failed to yield a solid phenylurethane
when tested with phenylisocyanate, and did not solidify
when cooled to —20°.

Nitrosochloride.—Both fractions when treated according
to the method of Wallach (see G. & H. "The Volatile
Oils," Vol. 1, pp. 379/80) yielded nitrosochlorides melting
at 115-116° (see *M. linariifolia*, p. 313).

Oxidation to 1-2-4-trioxyterpane.—50 c.c. alcohol frac-
tion, No. 1, 36 grams potassium permanganate, 3600 c.c.
water and 2000 grams ice were treated according to the
procedure described under *M. linariifolia*, p. 315.   The
glycol, on repeated purification from a mixture of ether
and chloroform, melted at 112-115°:—0.4322 gram in
absolute ethyl alcohol gave a reading of + 0.8°, $[a]_D^{17°}$
+ 18.5°.

Napthylurethane.—When equal volumes of both frac-
tions of the alcohol were treated with equal volumes of

napthylisocyanate respectively they reacted completely in the course of a few days.   The respective derivatives were separated and purified from dilute methyl alcohol, when they melted at 104.5°-105.5°.   No depression of melting point was observed when mixed with the napthylurethane of Δ¹-terpinenol-4 received from Messrs. Schimmel & Co.

The alcohol present in this oil has thus been proved to be identical with Δ¹-terpinenol-4.

Determination of Sesquiterpenes.—The higher boiling portion of the crude oil examined boiling above 120° at 10 mm. was repeatedly distilled at the same pressure until the following fractions consisting of pale yellow coloured liquids were obtained.   They were purified finally over metallic sodium :—

Boiling point 10 mm.	Quantity	Specific gravity $\frac{15°}{15°}$	Optical rotation.	Refractive index 20°
121-129	30 c.c.	0·9265	+ 9·5°	1·4966
130-133	66 c.c.	0·9265	+ 12·78°	1·5045
134-138	25 c.c.	0·9345	+ 14·55°	1·5067

All three fractions when treated with dry HCl. gas in dry ether solution gave good yields of dihydrochlorides melting at 118-119°; 0.1458 gram in 10 c.c. chloroform gave a reading of —0.75°, $[a]_D^{20°} = -51.4°$.

The fractions also gave the usual colour reactions with bromine vapour in acetic acid solution and sulphuric acid in acetic anhydride.   The foregoing evidence points to one of the sesquiterpenes being cadinene or one yielding cadinene dihydrochloride.

Determination of Sesquiterpene Alcohol.—The residue left over after the removal of the sesquiterpenes by fractional distillation was distilled at 5 mm., when the follow-

ing somewhat viscous and dark coloured liquid was obtained:—Boiling point 131-138° at 5 mm., specific gravity $\frac{15°}{15°}$ 0.9508, optical rotation +6.8°, and refractive index 20° 1.5045. It was treated with twice its volume of 90% formic acid on a boiling water-bath, when water was readily removed. The sesquiterpene thus obtained was distilled several times over metallic sodium, when 13 c.c. of a pale lemon yellow coloured liquid was obtained. It possessed boiling point 134-138° at 10 mm., specific gravity $\frac{15°}{15°}$ 0.9216, optical rotation —4.6°, and refractive index 20° 1.5076. It gave the usual colour reactions mentioned for sesquiterpenes, as well as an excellent yield of dihydrochloride of melting point 118.5°. The sesquiterpene alcohol appears to be the corresponding one to the principal sesquiterpene, cadinene.

Determination of Phenolic Constituent (from 2,500 c.c. crude oil).—The portion of oil boiling above 190° at 770 mm. which had been treated with 8% sodium hydroxide solution, was washed a number of times with ether to remove traces of dissolved oil. The alkaline liquor on treatment with dilute sulphuric acid and extraction with ether yielded 0.5934 gram of a crude phenolic body, which gave an indistinct brownish green colouration with ferric chloride in alcoholic solution.

My thanks are due to the following:—Mr H. R. Lyons, Forest Guard, Grafton (Forestry Commission of New South Wales), for his kindness in arranging for the collection of the whole of the material examined from Copmanhurst; Mr. F. R. Morrison, A.S.T.C., A.A.C.I., Assistant Economic Chemist, for much assistance in the investigation; and Mr. F. O'Donnell, Laboratory Assistant, for the preliminary fractional distillation of the crude oil (22/8/24) and for the extraction of the cineol from the various terpene fractions.

NOTE ON THE EARTHQUAKES AT MURRUMBATE-MAN DURING MARCH AND APRIL, 1924, AND JANUARY TO APRIL, 1925.

By LEO. A. COTTON, M.A., D.Sc.,

Professor of Geology, University of Sydney.

(With Map.)

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The district lying to the south-east of Yass and extending southward to the northern border of Victoria is one of the most unstable areas of continental Australia. A considerable number of earthquakes and earth tremors have been recorded from this area, but there is no record of so many shocks occurring in so short a time as those recently experienced during March and April of 1924. Altogether, nine or ten shocks were recorded from the 7th March to 26th April inclusive.

I am indebted to many residents of the district for information, and particularly to Mr. A. J. Shearsby of Yass, who has kindly supplied me with all the information which he was able to obtain as the result of his personal enquiries throughout the district.   ,

The most disturbed centre was in the immediate vicinity of the town of Murrumbateman, which lies about 12 miles to the south-east of Yass. A list of the earthquakes recorded is as follows:—

Year 1924.

No. 1 Friday, 7th March, at 9.45 a.m.
 „ 2 Saturday, 8th March, at 4.30 p.m.
 „ 3 Wednesday, 19th March, at 6.45 a.m.
 „ 4 Monday, 24th March, at 10.30 p.m.
 „ 5 Wednesday, 26th March, at 5 p.m.
 „ 6 Tuesday, 1st April, at 11.5 p.m.
 „ 7 Wednesday, 2nd April, at 4.20 a.m.
 „ 8 Tuesday, 15th April, at 9 30 p.m.
 „ 9 Friday, 25th April, at 6 p.m.
 „ 10 Saturday, 26th April, at 12.5 a.m.

Year 1925.

No. 11 January 15th, at 9.20 p.m.
 „ 12 February 18th, at 9.30 a.m.
 „ 13 March 15th, at 6.0 p.m.
 „ 14 March 31st, at 8.0 p.m.
 „ 15 April 1st, at 3.30 a.m.

The first earthquake was by far the most severe, and was felt over a considerable area, as indicated by the accompanying map showing the position of the isoseismals. At the town of Murrumbateman the shock was exceptionally severe; articles were thrown down from shelves, and the plaster fell in several houses, being thrown right across the room from the north west wall to the south east in one case. The ground was observed to heave and wave, and fences and trees rocked perceptibly. A 1,000-gallon-water-tank swayed in an alarming manner. A study of the accompanying map showing the isoseismals presents some interesting features. The isoseismals are elongated in two directions, and this suggests that the earth movement took place along two intersecting faults, one having a north-south and the other an east-west trend.

The second earthquake was also most pronounced at Murrumbateman, where water was thrown over the top of a tank as the result of the shock.

The third earthquake was felt slightly at Murrumbateman, Yass, and Cook's Hill, which is about 10 miles north of Yass. It was felt more severely at Gunning, where it was stronger than the first earthquake of 7th March.

The fourth earthquake was felt by several persons at Murrumbateman.

The fifth earthquake was felt only at Murrumbateman.

The sixth earthquake was felt both at Yass and Murrumbateman.

The seventh earthquake was recorded at Yass by one observer only, who was awakened by the movement. This must be regarded as doubtful.

The eighth earthquake was reported from Murrumbateman and Nanima, a few miles distant.

The ninth and tenth earthquakes were reported only from Murrumbateman.

The eleventh earthquake was felt by a number of persons in the vicinity of Wee Jasper.

The twelfth earthquake was a slight shock reported only from Murrumbateman.

The thirteenth earthquake was felt at Murrumbateman, Bungendore and Braidwood, being most severe at the latter town.

The fourteenth earthquake was felt at Murrumbateman, where it dislodged plaster from a ceiling.

The fifteenth earthquake was felt at Murrumbateman, where it awakened many people.

The features of special interest in connection with these earthquakes are the frequency with which they occurred during the two months of March and April; and the peculiar form of the isoseismals of the earthquake of 7th March, 1924.

Note - The intensities of the isoseismals
are those of the Rossi - Forel Scale
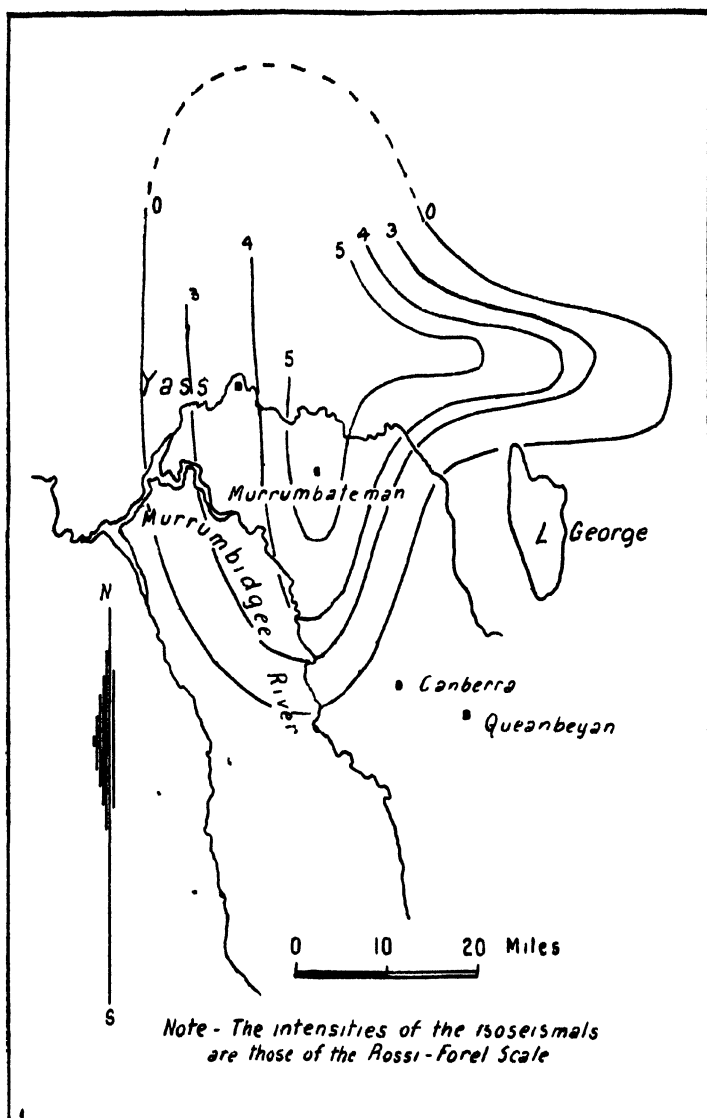
THE IDENTIFICATION OF THE PRINCIPAL IRONBARKS AND ALLIED WOODS.

By M. B. WELCH, B.Sc.

(With Plates XV-XVI and Text Figures.)

(Read before the Royal Society of New South Wales, Nov. 4, 1925.)

Certain Eucalypts possessing a hard, rough, deeply furrowed bark are called Ironbarks. The timbers of some species possess great strength and durability, and are undoubtedly among our most valuable hardwoods for constructional purposes. Altogether about twenty species fall into the class *Schizophloiœ* or Ironbarks, but of these the most important are *E. paniculata,* Sm., Grey or White Ironbark; *E. crebra,* F.v.M., Narrow-leaved Ironbark; *E. siderophloia,* Benth., Broad-leaved Ironbark; *E. sideroxylon,* A. Cunn., Red-flowering Ironbark or Mugga.

Two species of which the wood is frequently confused with that of the Ironbarks are *E. punctata,* D.C., and *E. propinqua,* Deane & Maiden; both trees have smooth barks and are known as Grey Gum. It is often a very difficult matter to identify the woods of these two groups with certainty, and it is, therefore, proposed to describe their structure in some detail.

R. T. Baker[*] described the anatomical characters of four Ironbarks, namely, *E. paniculata,* Sm.; *E. Fergusoni.* R.T.B.; *E. Nanglei,* R.T.B., *E. Beyeri,* R.T.B.; the latter three being species allied to, and often mistaken for, *E. paniculata.*

[*] R. T. Baker, Some Ironbarks of N.S.W., Vol li, This Journal, p. 410, 1917.

It is very difficult to separate the woods on general external characters, although those constantly handling the timbers undoubtedly become very expert at their identification. A very useful list of tests which can be used to discriminate between the Grey Gum and Ironbark groups is given in a bulletin issued by the New South Wales' Forestry Department.* Owing to variation which undoubtedly occurs in the weight, hardness, closeness of texture, and even to some extent in the colour, exceptions offer occur to the general rules, which make the problem by no means an easy one. One test often quoted is the tenacity in breaking of a sliver of the wood, Grey Gum being said to be more brittle than the Iron-barks. This does not always hold, however (although *E. paniculata* is in general tougher than the other woods), and is quite unreliable. Similarly "interlocked grain" is not a constant character, although some woods are more prone to this feature than others. One of the most reliable indications is probably the presence of concentric "gum veins" in the wood of the Grey Gums, whereas they apparently do not occur in the wood of the Ironbarks. Although gum pockets may occur in the latter group, kino· is usually confined to the bark, in this respect differing from practically all other Eucalypts. It should be noted, however, that gum veins are frequently absent from the timber of Grey Gum. The end checking of logs is often a useful indication, since Grey Gum normally splits radially, whereas Ironbark usually has small radial and concentric checks, breaking up the end surface into irregular squares.

A method of separation of the two groups which is some-times mentioned depends on a supposed constant variation

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* P. J. Drew. Identification of Timbers, Bull. No. 7, Dept. of Forestry, N.S. Wales, 1914.

in their densities; thus a chip of Grey Gum is said to float, whereas the Ironbark sinks. The variation of the specific gravity in any one species renders such methods absolutely unreliable, and also misleading.

The principal macroscopic and microscopic features of the woods are given in the following descriptions:—

<div align="center">

E. PANICULATA, Sm.

White or Grey Ironbark.

</div>

A large forest tree found in the coast districts of New South Wales and Queensland. The wood is pale to brownish in colour, sometimes pinkish, moderately open textured, very heavy; weight per cubic foot 62-72 lbs. Hardness = Very hard.

Macroscopical characters.—Pores of medium size, easily seen with the naked eye, usually in oblique rows, more crowded at intervals, this constituting the only indication of growth rings. Soft tissue not apparent. Rays invisible on end section without pocket lens, more prominent on a radial face, being somewhat darker than the ground tissue.

Microscopical characters.—Pores usually single, often in oblique rows of 2–4; single pores elliptical; radial diameter 75–180μ; mean 130μ; tangential diameter 35–95μ, mean 80μ; vessel segments 100–400μ in length; walls 5–7μ; lateral pits not crowded, slit like, border often indistinct, circular or almost so, pits in contact with ray cells larger, irregular in shape, simple; end perforation simple; end wall transverse or slightly oblique; tyloses invariably present; average number per sq. mm., 16.

Wood fibres very thick walled, in radial rows, average diameter 15μ; lumen often reduced to 1μ; length 600–1,500μ; pitting slit like, definitely bordered and therefore corresponding to fibre-tracheids. Gradations occur from the fibre-tracheids to moderately thin walled

tracheids, which are irregular in shape, often blunt ended
and measuring up to 700μ in length by 15μ in diameter;
pitting crowded, bordered. Tracheids usually occur only
in close proximity to the vessels.

Wood parenchyma diffuse or principally vasicentric, not
abundant and less than in any other species, cells usually
with dark contents. Chambered crystal parenchyma
present.

Rays usually uniseriate, 1–14 cells in height; very rarely
biseriate, and measuring up to 275μ in height and 12μ in
width; cells moderately thick walled; usually with light
greenish coloured amorphous contents, often with a ten-
dency to become heterogeneous; 10–13 per mm. of trans-
verse section. Smoulders to fawn-coloured ash, with little
unburnt carbon*. Alcoholic extract pale yellow to yellow,
no turbidity on adding water, no fluorescence. Aqueous
extract yellow to brown, clear; bluish colouration with
ferrous sulphate; slight precipitate with lead acetate.

<div align="center">

E. CREBRA, F.v.M.

Narrow-leaved Ironbark.

</div>

A large forest tree found in the coast and part of the
western districts 'of New South Wales, extending into
Queensland and the Northern Territory. The wood is red
in colour, often interlocked in grain, often moderately
close in texture; very heavy, weight per cubic foot =
63-70 lbs. Hardness = Very hard.

Macroscopical characters.—Pores of small to medium
size, easily seen with the naked eye, usually single, some-
times occurring in oblique rows; growth rings defined by

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* It is interesting to note that *E. Beyeri, E. Fergusoni* and
' *E. Nanglei* smoulder to a fawn ash, but leave a certain amount
of unburnt carbon, especially in the latter case.

the crowding of the pores in concentric unevenly spaced
zones. Soft tissue not visible. Rays very fine, only visible
on end section with lens, but easily visible on a radial
surface, of very little difference in colour to surrounding
tissue, not seen on a tangential section.

Microscopical characters.—Pores usually single, often in
pairs, obliquely or radially arranged, single pores
elliptical; radial diameter 35–200μ; mean 120μ; tangential
diameter 25–125μ, mean 90μ; vessel segments 200–500μ;
walls 5–7μ; lateral pits narrow, elliptical or slit-like,
borders circular or elliptical, ray pits irregularly elliptical,
simple; end walls almost transverse or slightly oblique; end
perforation always simple; tyloses practically always
present in heartwood, not in sapwood; pores often filled
with dark amorphous phlobaphene-like body; number per
sq. mm., 13–24. Wood fibres thick walled, in radial rows;
average diameter 15μ, lumen very small, often reduced to
1μ; length 600–1,350μ, pits slit-like, bordered. Gradations
occur between the fibre-tracheids which constitute the bulk
of the wood and tracheids, the latter measuring up to 600μ
in length and 30μ in diameter, with numerous bordered
pits, or simple in contact with ray cells. Wood parenchyma
not abundant, diffuse or vasicentric, cells usually with
dark contents. Rays uniseriate or biseriate; uniseriate
rays 2–14 cells in height, biseriate rays up to 450μ in
height and 25μ in width; outer cells often somewhat irregu-
lar in shape, and deeper than middle cells; 11–14 per mm.
of transverse section. Usually does not smoulder, all
unburnt carbon, or sometimes with little ash. Alcoholic
extract orange yellow; slight turbidity on adding water, no
fluorescence. Aqueous extract yellow to brown, turbid;
blue with ferrous sulphate; slight to heavy precipitate with
lead acetate.

E. SIDEROPHLOIA, Benth.

Broad-leaved Ironbark.

A large forest tree found on the coast and portion of the interior of New South Wales and Queensland. Wood, red in colour, often somewhat open in texture; grain often interlocked; very heavy, weight per cubic foot = 65–73 lbs. Hardness = Very hard.

Macroscopical characters.—Pores small to medium in size, easily seen with the naked eye, usually single, often in irregularly oblique rows, crowded into lighter coloured concentric zones corresponding to growth rings. No soft tissue apparent. Rays very fine, not visible on end or tangential sections without lens, visible radially without difficulty, being darker than ground tissue.

Microscopical characters.—Pores usually single, occasionally in pairs, very variable in size and unevenly distributed; single pores usually elliptical, though often circular; radial diameter 55–180μ, mean 110μ; tangential diameter 40–125μ, mean 90μ; vessel segments 300–450μ, walls very thick, 6–10μ; lateral pits in contact with tracheids, wood parenchyma and intravascular pits crowded, elliptical or slit-like, borders circular or elliptical, ray pits large, irregular rounded, simple; end perforation always simple; end wall transverse or slightly oblique; end projection short; tyloses usually present, cells often with brownish clear amorphous contents; number per sq. mm., 12–18. Wood fibres very thick walled in radial rows; mean diameter 15μ, lumen often reduced to 2μ; length 650–1,300μ; pits usually slit-like, very definitely bordered. Transition stages occur from these fibre-tracheids to irregularly shaped, often blunt ended tracheids with numerous bordered pits, simple in contact with rays; measuring up to 750μ in length and 18–35μ in diameter.

Wood parenchyma not abundant, diffuse or vasicentric; cells often with amorphous brown contents. Rays uni-seriate or biseriate; uniseriate rays 2–18 cells in height; biseriate rays up to 25μ in width and 350μ in height, with a tendency to become heterogeneous, outer cells usually deeper; cells with reddish brown amorphous or granular contents.

Burns without smouldering, all unburnt carbon.

Alcoholic extract orange yellow; turbidity on adding water, no fluorescence. Aqueous extract yellow to light brown, turbid; bluish colouration with ferrous sulphate; very slight precipatate with lead acetate.

<div align="center">

E. SIDEROXYLON, A. Cunn.
Mugga, Red-flowering Ironbark.

</div>

A large forest tree with an exceptionally furrowed bark, found over a large area of New South Wales, Victoria and Queensland. Wood, reddish in colour, moderately open in texture, often with an interlocked grain; very heavy; weight per cubic foot, 60–70 lbs. Hardness = Very hard.

Macroscopical characters.—Pores small to medium in size, easily visible with the naked eye, single or often in oblique irregular rows, more crowded in portion of growth ring. No soft tissue apparent. Rays not visible on end or tangential section without lens, but easily seen on a radial surface, being darker in colour than the surrounding tissue.

Microscopical characters.—Pores usually single, rarely in pairs, obliquely or radially distributed; very variable in size and unevenly distributed; single pores elliptical, rarely circular; radial diameter 55–190μ, mean 125μ; tangential diameter 40–150μ, mean 110μ; vessel segments 150–350μ, walls 6–8μ; lateral pits crowded, more or less slit-like in contact with vertical wood elements, with circular or ellip-tical borders; large and simple in contact with ray cells;

end perforation simple; end walls transverse or slightly oblique; end projection wanting or small; tyloses abundant; number per sq. mm. 11–16. Wood fibres in radial rows, very thick walled; average diameter 14μ, lumen often reduced to 2μ; length 600–1,400μ. Transition stages occur to heavily pitted tracheids measuring up to 700μ in length and 18μ in diameter. Wood parenchyma with tendency to form zones, diffuse or vasicentric; cells with dark amorphous contents. Rays mostly biseriate, up to 350μ in height and 37μ in width, but rarely exceeding 25μ; uniseriate rays 1–6 cells in height, cells with brown amorphous contents; rays often tend to become heterogeneous; 11–15 per mm. of transverse section.

Burns without smouldering, all unburnt carbon.

Alcoholic extract orange red; slight turbidity on adding water, no fluorescence. Aqueous extract brown, turbid; bluish colouration with ferrous sulphate; slight precipitate with lead acetate.

<div align="center">

E. PUNCTATA, DC.

Grey Gum.

</div>

A large forest tree found in the coastal districts of New South Wales and Southern Queensland. The wood is reddish in colour, moderately close in texture, often interlocked in grain and very heavy. Weight per cubic foot, 61–65 lbs. Hardness = Hard.

Macroscopical characters.—Pores usually medium in size, easily seen with the naked eye, more crowded at intervals, often in oblique rows. Soft tissue not visible. Rays on end section often visible with naked eye as very fine lines, visible with difficulty on a tangential surface, readily seen on radial sections; darker in colour than ground tissue.

Microscopical characters.—Pores usually single, very rarely in pairs, very variable in size and uneven in distri-

bution; single pores usually elliptical; radial diameter
50–270μ, mean 180μ; tangential diameter 50–155μ, mean
120μ; vessel segments 240–500μ; walls 4–6μ; lateral pitting
in contact with vertical elements crowded, slit-like; borders
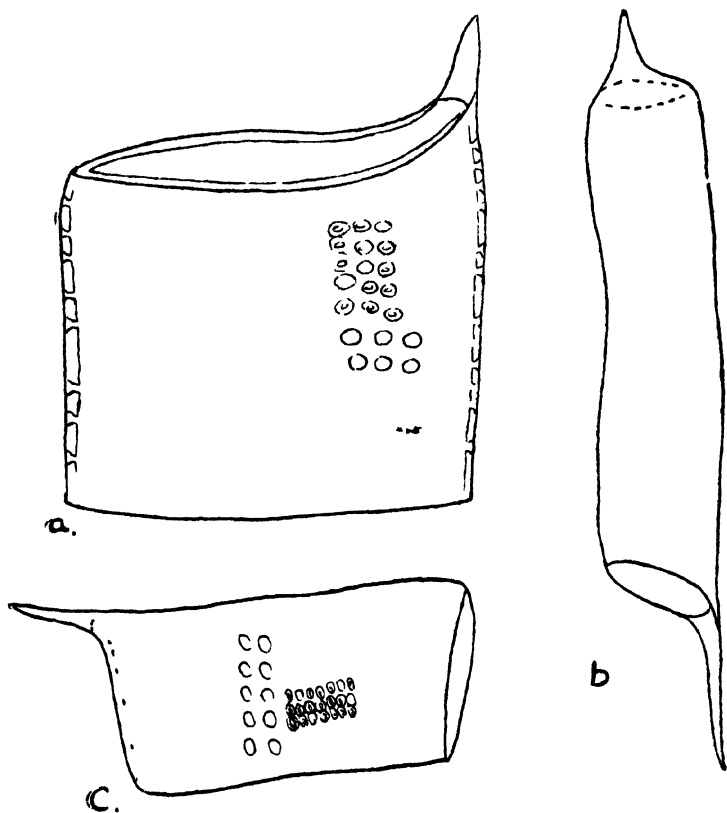
Fig. 1.

a = Vessel segment, $E.\ propinqua$, showing a few simple
and bordered pits × 140. b = vessel segment, $E.\ siderophloia$,
pitting not shown, × 140. c = vessel segment $E.\ crebra$,
showing a few of the pits, × 140.   The vessels show the
simple end perforation and the oblique or almost transverse
end walls.

circular or elliptical; ray pits rounded, simple; end perforation simple; end walls slightly oblique or transverse; end projection small or wanting; tyloses usually present; 10–20 per sq. mm. Wood fibres thick walled, in radial rows; mean diameter 14μ, lumen often reduced to 2μ; length 750–1,400μ; pits slit-like, bordered. Transitions occur to tracheids with numerous pits, usually bordered, except in contact with rays, and measuring up to 900μ in length and 30μ in diameter. Wood parenchyma abundant, diffuse or vasicentric, often crowded into zones; cells usually with dark contents. Rays usually biseriate, often triseriate, up to 375μ in height and 45μ in width; uniseriate rays 1–15 cells in height, cells with brown amorphous or granular contents; 8–12 per mm. of transverse section.

Burns without smouldering, all unburnt carbon.

Alcoholic extract orange to orange red; no turbidity on adding water, no fluorescence. Aqueous extract yellow to reddish brown, turbid; bluish green to green with ferrous sulphate, heavy precipitate with lead acetate.

<div style="text-align:center">

E. PROPINQUA, Deane & Maiden.
Small-fruited Grey Gum.

</div>

A very large forest tree found on the coastal district of northern New South Wales and Queensland. The wood is reddish in colour, moderately close in texture, often interlocked in grain and very heavy. Weight per cubic foot, 61–70 lbs. Hardness == Hard.

Macroscopical characters.—Pores small to medium in size, easily seen with the naked eye, more crowded at intervals, corresponding to growth rings, often in oblique rows. Soft tissue not visible. Rays not seen on end or tangential sections without the assistance of a lens, but easily seen on a radial surface, being darker than the ground tissue.

Microscopical characters.—Pores usually single, but often in pairs obliquely or radially arranged, very variable in size, distribution uneven; single pores elliptical; radial diameter 35–320μ, mean 160μ; tangential
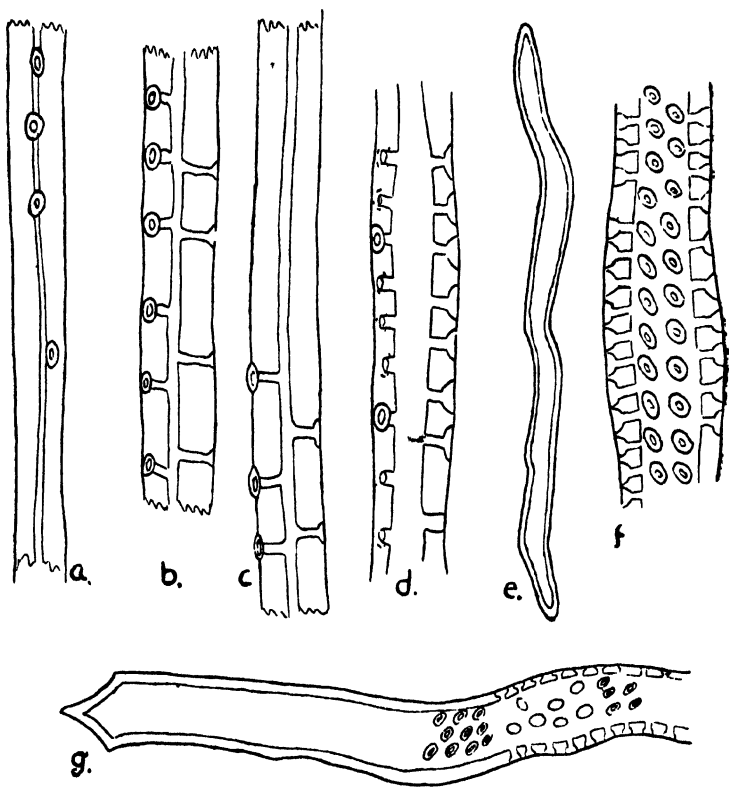
Fig. 2.

a, b and *c* = Portions of wood fibres (fibre-tracheids), showing bordered pits, *E. paniculata*, × 540. *d* = inter-. mediate stage between wood fibre and tracheid, *E. paniculata*, × 540. *e* = tracheid, *E. crebra*, × 130. *f* = portion of tracheid *(e)*, showing pitting, *E. crebra*, × 540. *g* = tracheid, *E. siderophloia*, showing simple and bordered pits, × 350.

diameter 37–200μ, mean 125μ; vessel segments 300–650μ; walls 4–6μ; lateral pits in contact with vertical elements crowded, border elliptical or circular; simple, rounded in contact with ray cells; end perforation simple; end walls transverse or slightly oblique, end projection small or wanting; tyloses abundant; number per sq. mm. 6–18. Wood fibres in radial rows, thick walled, average diameter 15μ, lumen reduced to 2μ; length 750–1,650μ; pits slit-like, borders elliptical or almost circular. Transition stages occur to irregularly shaped often blunt ended tracheids measuring up to 800μ in length, and 26μ in diameter. Wood parenchyma abundant, principally vasi-centric or diffuse; cells often with dark contents. Rays commonly biseriate, more rarely triseriate, up to 700μ in height and 33μ in width; uniseriate rays 2–16 cells in height; cells often with brownish amorphous contents, 11–14 per mm. of transverse section.

Smoulders without burning, all unburnt carbon.

Alcoholic extract orange yellow; sometimes turbid on adding water, no fluorescence. Aqueous solution yellow-brown, turbid; bluish green with ferrous sulphate, heavy precipitate with lead acetate.

From an examination of the microscopic structure of the woods it is evident that there are few features which appear to be˘ of value for diagnostic purposes. The majority of the structures, for example wood fibres (fibre tracheids), tracheids and vessels do not exhibit any marked constant variation, one from another. Thus in a specimen of *E. crebra* from Dubbo the maximum radial pore diameter was 130μ, whereas in a piece of the same wood from Thirlmere, a region of higher rainfall, the maximum radial

diameter was 200μ. The variation in pore size in different parts of the same log has been mentioned in a previous paper.*

In every case the ground mass of the wood consists of wood fibres with more or less prominently bordered pits, the so-called fibre tracheids, which have not been found to exceed 1,700μ in length. The fibres in the Eucalypts are
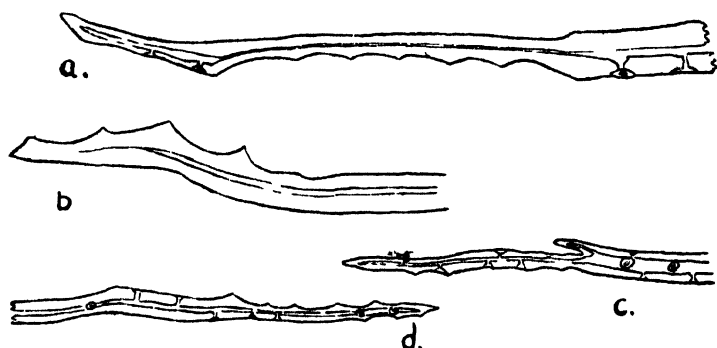
Fig. 3.

Portions of fibre ends showing typical interlocking serra-tions commonly found in *Eucalyptus* timbers. a = *E. pani-culata* × 560. b = *E. paniculata* × 640. c and d = *E. crebra*, × 130.

by no means remarkable for their length, the toughness of certain species, e.g., *E. paniculata,* etc., seeming to depend on the development of interlocking serrations near the fibre ends. The development of bordered pits on the fibre cells is especially prominent in *E. siderophloia.* The tracheids are usually irregular in shape, often blunt ended with numerous bordered pits, where they are in contact with

* M. B. Welch. Note on the Structure of some Eucalyptus Woods, This Journal, Vol. lviii., p. 176, 1924.

other tracheids or vessels, or with simple pits in contact with the ray cells. It is possible to find every gradation from prosenchymatous fibre-tracheids with comparatively few pits to spindle-shaped cells with more numerous bordered pits, and finally to the irregularly shaped, comparatively thin walled tracheids.

The vessel segments are exclusively with simple end perforation, and in the case of heartwood almost invariably plugged with tyloses (tyloses are absent in the sap-wood). The end walls are transverse or slightly oblique, and the end projection usually small or even wanting. Wood parenchyma is more abundant in the Grey Gums than in the Ironbarks. One feature which appears to be of some value in the identification of the woods is the ray. These are only visible with the naked eye in *E. punctata,* and are often triseriate in that species and in *E. propinqua.* In *E. paniculata* they are almost without exception uniseriate; in *E. siderophloia* and *E. crebra* they are both uniseriate and biseriate, whilst in *E. sideroxylon* they are chiefly biseriate.

It is interesting to note that with only one exception the woods of the species examined did not smoulder, but left a residue consisting practically of unburnt carbon; the exception, *E. paniculata,* smouldered away almost completely to a light coloured ash. This held good in all material tested. The extracts, both alcoholic and aqueous, were disappointing, as too much variation was found in the colour and behaviour of the individual species to make them of much value. One character worthy of note was the greenish colouration obtained by the addition of ferrous sulphate to the aqueous extracts of *E. punctata* and *E. propinqua;* however, exceptions to this might possibly be found.

The following key is based on what appear to be the principal points of difference, and summarises the investigation.
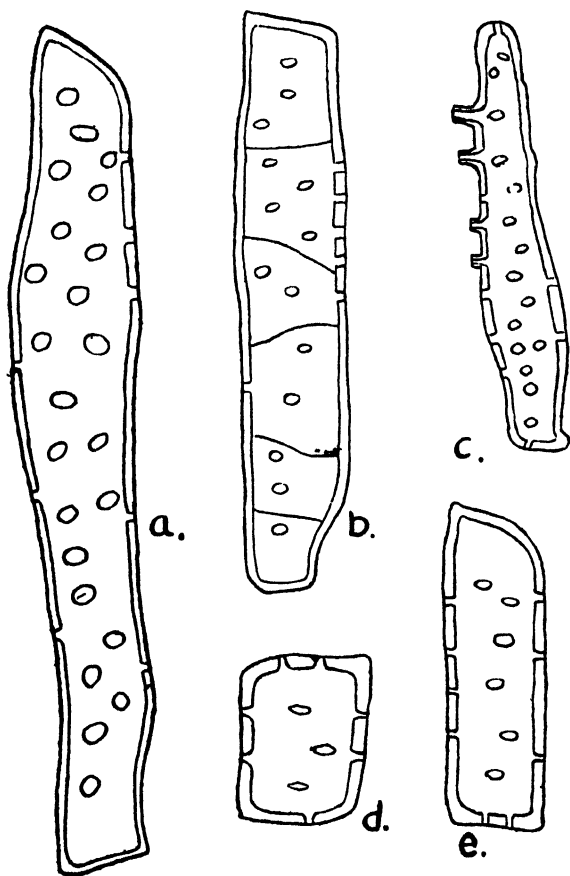
Fig. 4.

a = Wood parenchyma cell showing simple pitting, *E. siderophloia*, × 600. b = Wood parenchyma cell with thin cross walls, *E. paniculata*, × 600. c = Conjugate parenchyma cell, *E. siderophloia*, × 390. d and e = Ray cells, *E. crebra*, showing simple pitting, × 600.

Key to the Timbers.

(a)

Rays sometimes triseriate.

(b)

Rays rarely triseriate, narrow, up to 700μ in height, not visible with naked eye on end section; wood parenchyma cell contents not prominent, chiefly vasicentric.

E. propinqua.

(b_1)

Rays often triseriate, broad elliptical, up to 375μ in height, often visible on end section with naked eye; wood parenchyma cell contents dark in colour, prominent, largely diffuse.

E. punctata.

(a_1)

Rays uniseriate or biseriate.

(c)

Rays practically all uniseriate; wood pale to brown or pink in colour, not red, burns to ash.

E. paniculata.

(c_1)

Rays uniseriate or biseriate, wood red in colour, does not burn to ash.

(d)

Rays practically all biseriate, short and broad, average width 30μ, uniseriate rays rarely exceeding 6 cells in height.

E. sideroxylon.

(d_1)

Rays uniseriate and biseriate, average width 15μ, uniseriate rays up to 18 cells in height.

(e)

Pits on walls of fibre-tracheids prominent; rays darker than ground tissue on a radial surface.

E. siderophloia.

Fig 1 —*Eucalyptus paniculata*   x 110

Fig. 2.—*Eucalyptus sideroxylon.*   x 110.

Fig. 1.—*Eucalyptus punctata*   x 110
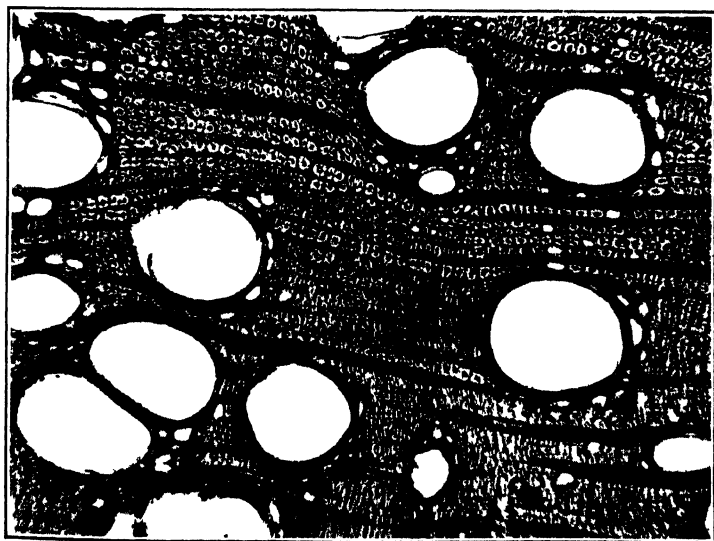
Fig. 2.—*Eucalyptus crebra.*   x 110.

(e_1)

Pits on fibre-tracheid walls not prominent; rays practically same colour as ground tissue on a radial surface.

E. crebra.

EXPLANATION OF PLATES.

PLATE XV

Fig. 1.—Longitudinal tangential section of wood of *E. paniculata,* Sm., showing typical uniseriate rays and portion of a vessel partially filled with tyloses. X 110.

Fig. 2.—Longitudinal tangential section of wood of *E. sideroxylon,* A. Cunn, showing broad biseriate and a few short uniseriate rays. The pitting on the fibre-tracheid walls is prominent. Portion of a vessel is seen partially filled with tyloses. X 110.

PLATE XVI.

Fig. 1.—Longitudinal tangential section through wood of *E. punctata,* DC., showing triseriate rays. X 110.

Fig. 2.—Transverse section of sap-wood of *E. crebra,* F.v.M., showing complete absence of tyloses. The arrangement of the pores and the extreme variability in pore size is typical of the Ironbarks. The pitting in the walls of the vessels and fibre tracheids, etc., can be seen. The wood parenchyma is not abundant, and is vasicentric or diffuse. X 110.

Technological Museum,
    Sydney.

THE GERMICIDAL VALUES OF SOME AUSTRALIAN ESSENTIAL OILS AND THEIR PURE CONSTITUENTS.

TOGETHER WITH THOSE FOR SOME ESSENTIAL OIL ISOLATES, AND SYNTHETICS.

PART III.

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(Read before the Royal Society of New South Wales, Dec. 2, 1925.)

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The following tables represent a further continuation of our investigations published in this Journal for 1923 and 1924 (Vols. LVII., pp. 211-215, and LVIII., pp. 117-123), treating of the Rideal-Walker coefficients of Essential Oil Constituents, Isolates and Synthetics.

In the last mentioned paper a series of esters of valerianic acid were examined, and on this occasion a series of esters of a particular alcohol, butanol, were tested with very interesting results, the high coefficient for butyl butyrate being especially noteworthy. In this connection, it is necessary to remark that the esters were purified from an an exhibit of commercial butyl esters kindly donated to the Technological Museum by the Commercial Solvents Corporation of Terre Hauete, Indiana, U.S.A.

The opportunity is also taken of correcting the Rideal-Walker coefficient of terpineol published in this Journal (Vol. LVII. (1923), p. 87). It is given as 7.5, but subsequent investigation has failed to confirm this result, the correct number being 16. The only explanation that can

be advanced is that in the earlier preparation the terpineol had been poorly dispersed.

In connection with the dispersion of the different alcohols, phenols, etc., in soap solution, certain difficulties are encountered in their preparation. Especially is this so in the case of some of the alcohols, taking terpinenol-4 as an example, one preparation may give a coefficient of 13, whilst in another, the coefficient may fall to 11 or 12. Clearly this depression of the coefficient is brought about by the difference in the size of the particles. Slight alteration of the temperatures during preparation, or impurities in the rosin and sodium hydroxide used, may influence the dispersion. It may be called hypersensitiveness of the active constituent.

Phenols, on the other hand, do not exhibit this hypersensitiveness. Their coefficients remain practically constant, i.e., they are ideally dispersed.

It will also be observed that considerable differences exist between the coefficients as determined in either aqueous or soap suspensions, and in alcohol, and this is due to the varying degree of dispersion as pointed out in a previous contribution.

An interesting feature of these investigations is that the determination of the Rideal-Walker coefficient has been found to be of considerable value in the rapid detection of small quantities of cymene in admixture with terpenes. The coefficients of the great majority of terpenes so far examined do not exceed 3, and it was with this object in view that the carenes recently isolated from Indian essential oils by Dr. J. L. Simonsen were examined. The value of the test was demonstrated in the coefficient determined for a "terpene" isolated from the essential oils of *Melaleuca linariifolia* and *M. alternifolia* which consisted of a and γ terpinene and cymene, the number being 6.

Pure cymene has a coefficient of 8, but when present in admixture with terpenes it raised the number out of all proportion to the percentage it bears to the other constituents. Therefore, if a terpene of boiling point below 180° possesses a coefficient over 3 it can safely be assumed that it is a mixture containing cymene. This phase of the subject is being prosecuted further, and meanwhile we have applied the term "Biometric Test" to this form of analysis.

Experimental.

The Rideal-Walker tests were carried out as described in previous papers (this Journal, Vol. LVI., 1922, 219-226), standard suspensions of 1% of the bodies referred to being prepared in 7½% rosin-soap solution, with the exception of formic acid, and normal butyric acid, which were prepared in aqueous solution. Others, such as butanol, butaldehyde, butyl butyrate and butyl oxalate were also prepared in ethyl alcohol solution.

TABLE "A." Crude Essential Oils.

Crude oil	Constants (R.I.-refractive index)		Rideal–Walker Coefficients	Principal active constituents.
Atherosperma moschata	Sp. gr.	1.0225	18	Methyl eugenol,
	Opt. rot.	+8.75°		Safrol
	R.I.	1.5171		Camphor
	OCH₃	15.56%		(unknown bodies)
				Citronellol (80%)
Boronia citriodora	Sp. gr.	0.8814	12	
	Opt. rot.	+3.8°		
	R.I.	1.4611		
Dacrydium Franklini	Sp. gr.	1.0443	10	Methyl eugenol
	Opt. rot.	+0.7°		
	R.I.	1.5322		
Eriostemon myoporoides	Sp. gr.	0.8580		Terpenes (Pinene,
	Opt. rot.	+36.75°	8	Ocimene, etc.)
	R.I.	1.4690		
Melaleuca linariifolia	Sp. gr.	0.8992		Terpinenol-4
	Opt. rot.	+3.3°	10	Cymene
	R.I.	1.4748		
Melaleuca alternifolia	Sp. gr.	0.8961		Terpinenol-4
	Opt. rot.	+7.4°	11	Cymene
	R.I.	1.4782		
Melaleuca uncinata	Sp. gr.	0.984	5	Cineol (50%)
	Opt. rot.	+8°		
	R.I.	1.4727		

TABLE "B." *Essential Oil Constituents, Isolates and Synthetics.*

Constituent.	Nature.	Source.	Constants. (Sp gr. 15/15° R L-refractive index, 20°.)	Co-efficient.
*d-*Δ-4-Carene	terpene	Dr. J. L. Simonsen from Indian essential oils	B.Pt. 761 mm., 165-167° Sp. gr. 0.8632 Opt. rot. +56.8° R.I. 1.4769	3.5
*d-*Δ-3-Carene	do.	do.	B.Pt. 760.5 mm., 166.5-168° Sp. gr. 0.8683 Opt. rot. +5.3° R.I. 1.4730	4.0
Terpene (*a* and γ terpinene, cymene)	do.	*Melaleuca alternifolia*	B.Pt. 176-180° at 753 mm. Sp. gr. 0.8511 Opt. rot +2.25° R.I. 1.4759	6
Formic acid	acid	Museum stock	M.Pt. +8°	5
Butyric acid, normal	do.	Museum stock	B.Pt. 158-162° at 758 mm. Sp. gr. 0.9664 inactive R.I. 1.3969	1 (in distilled water) 8 (in ethyl alcohol)
Terpineol	alcohol	*E. Australiana* oil	B.Pt. 99-102° at 10 mm. Sp. gr. 0.9380 Opt. rot. —5.4° R.I. 1.4810	16
Terpineol	do.	Museum stock (Kahlbaum)	M.Pt. 35°	16
Terpinenol-4	alcohol	*Melaleuca linariifolia*	B.Pt. 93-96° at 10 mm. Sp. gr. 0.9847 Opt. rot. +14.2° R.I. 1.4794	12
do.	do.	*Melaleuca alternifolia*	B.Pt. 93-96° at 10 mm. Sp. gr. 0.9371 Opt. rot. +17.55° R.I. 1.4781	13.5
do.	do.	Schimmel & Co.	B.Pt. 92½-94° at 10 mm. Sp. gr. 0.9367 Opt. rot. +23.8° R.I. 1.4776	13

Phenyl ethyl alcohol	do.	Museum stock (Polak & Schwarz)	B.Pt. 104-105° at 10 mm. Sp. gr. 1.0264 inactive R.I. 1.5312	3
Butanol	do.	Museum stock (C. Solvents Corporation)	B.Pt. 115-118° at 767 mm. Sp. gr. 0.8173 inactive R.I. 1.3993	2 (soap solution) 5 (ethyl alcohol)
Butaldehyde	aldehyde	do.	B.Pt. 74-76° at 768 mm. Sp. gr. 0.8118 inactive R.I. 1.3796	12 (in soap solution) 5 (in ethyl alcohol)
Butyl butyrate	ester	do.	B.Pt. 69-70° at 20 mm. Sp. gr. 0.8748 inactive R.I. 1.4081	13 17 (in ethyl alcohol)
Butyl oxalate	do.	do.	B.Pt. 123-124° at 10 mm. Sp. gr. 0.9935 inactive R.I. 1.4230	under 1 6 (in ethyl alcohol)
Butyl tartrate	do.	do.	B.Pt. 175-177° at 5 mm. Sp. gr. 1.0924 Opt. rot. +12.5° R.I. 1.4451	under 1
Dibutyl phthalate	do.	do.	B.Pt. 122° at 5 mm. Sp. gr. 1.0579 inactive R.I. 1.4940	3

In conclusion, our thanks are due to Professor J. L. Simonsen, of Bangalore, India, for his kindness in furnishing specimens of the carenes, and to Mr. F. R. Morrison, A.S.T.C., A.A.C.I., for assistance in the chemical portion of the work.

THE ESSENTIAL OIL OF *BAECKEA GUNNIANA*
var. *LATIFOLIA* (F.v.M.).

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The botany of this interesting Myrtaceous plant is described in Bentham's "Flora Australiensis," Vol. III, p. 79. It is a densely branched erect shrub, growing to a height of five or six feet. It is widely distributed throughout New South Wales, having been recorded from Jenolan Caves, Medlow Bath, Wentworth Falls, Blackheath, Queanbeyan, Wingello, Tallong, Braidwood, Mount Kosciusko and Tantawanglo and Brown Mountains (E. Cheel).

Although it bears a close superficial resemblance to the type *B. Gunniana,* yet it can readily be distinguished from it, even in the herbarium. The difference in the essential oils, however, is most marked, as *B. Gunniana* yields a mobile oil high in terpenes, whilst the var. *latifolia* gives a solid of "buttery" consistency, low in terpenes. H. G. Smith described the essential oil from the first named in this Journal for 1922 (Vol. LVI., pp. 181-182), and noted that no crystalline body was detected in the oil. The essential oil from var. *latifolia* is hardly an oil in the strict sense of the word, as it soon solidifies to a fatty solid, varying in melting point from 43° to 47°. So far as I am aware, this is the first instance of an essential oil from Australian plants being solid at ordinary temperatures. This essential oil does not possess any commercial value,

but the results obtained by its examination are of considerable scientific interest from the viewpoint of botanical chemistry, and also on account of its high content of eudesmol, over 60%.

The Essential Oil.

The essential oils, as first obtained, were of a dark brown colour, very viscous, but possessed a pleasant terpenic odour, and solidified within a few hours to a solid of "buttery" consistency. Although widely distributed, I was unable to obtain material for oil distillation from more than one locality, but three collections were made in all during the period 1922-1925. Altogether, 268 lbs. of leaves and terminal branchlets were collected from Monga, on the Clyde Road, 12 miles from Braidwood, N.S.W. The principal constituents, which have so far been identified, are eudesmol (sesquiterpene alcohol), 60%, eudesmene, β-pinene, together with a small quantity of unidentified phenol and valerianic acid ester, and a yellow stearoptene, $C_{18}H_{18}O_4$, melting point $103\frac{1}{2}$-104°, first described in this Journal for 1922, Vol. LVI., pp. 87-89.

Experimental.

The 268 lbs. weight of leaves and terminal branchlets referred to, yielded on distillation with steam, crude oils, possessing the following physical and chemical characters:

Date.	Weight of leaves	Yield of oil.	M.Pt.	Specific gravity.	rotation Optical	Refractive index 20°
4/8/1922	81 lbs	0 74%	43°	0.9679 $\frac{18°}{(15°)}$	+15.6°	1.5059
23/4/1924	110 lbs.	0 83%	46½–47°	0.9550 $\frac{26°}{15°}$	+23.0°	1.5038
28/8/1925	77 lbs.	0.46%	45°	0.9578 $\frac{(15°)}{(15°)}$	+18.0°	1.5049

Solubility in 70% alcohol (by weight).	Ester No. hot sap.	Ester No. after acetylation.
Sol. in 3 vols.	15.73 (acid No. 2)	139.77
„ „ 3 vols.	11.44	138.38
„ „ 2 vols.	23.19	151.80

The sample of oil, 4/8/1922, was that utilised principally in the investigation on account of the larger quantity of oil available, and the greater proportion of lower boiling constituents.

One hundred and twenty c.c. of the crude oil were subjected to steam distillation in order to separate the terpene and (partially) the sesquiterpene from the large quantity of stearoptene. In this way 36 c.c. of mobile oil were obtained. On repeated fractional distillation the latter was resolved into two main fractions, one boiling below 70° at 10 mm., 7 c.c., and another at 128-142°, 20 c.c.

Determination of β-pinene.—The small fraction boiling below 70° at 10 mm. possessed the following physical characters:—Specific gravity, $\frac{15°}{15°}$ 0.8713, optical rotation + 2°, and refractive index, $20°$, 1.4742. A small portion tested for α-pinene failed to yield any trace of nitrosochloride. The remainder was oxidised with potassium permanganate in the presence of sodium hydroxide (see Vol. LIV. (1920), p. 204), when crystals of sodium nopinate were obtained. These, on treatment with dilute sulphuric acid yielded nopinic acid, which on recrystallisation from benzene melted at 125°.

Determination of Sesquiterpene.—The fraction 128-142° at 10 mm., 20 c.c., was repeatedly distilled at the same pressure over metallic sodium ,when the following final distillate was obtained:—boiling point, 129-132° at 10 mm., specific gravity, $\frac{15°}{15°}$ 0.920, optical rotation, —11.7°, and refractive index, $20°$, 1,5020.

It gave the two well known colour reactions usually obtained for sesquiterpenes from Australian essential oils, but failed to yield any solid derivatives characteristic of these bodies. In view of its association with such a large quantity of eudesmol, it is most probably identical with the corresponding sesquiterpene, eudesmene.

Determination of Eudesmol.—The residue left in the flask from the steam distillation of 120 c.c. crude oil was shaken with petroleum ether (B.Pt. below 50°), and the solution filtered from a yellow solid. This solution was washed with 8% sodium hydroxide solution to remove small quantities of phenolic bodies, and upon removal of the petroleum ether by distillation a white "buttery" solid remained. This was spread out on a porous plate for the removal of small quantities of adhering sesquiterpene, and subsequently purified by recrystallisation from ethyl alcohol and water until its melting point was raised to 79-80°. The crystals, besides possessing the same melting point, showed the usual characteristic physical properties of eudesmol. The crystals boiled at 156-158° at 10 mm., and on treatment with dry hydrochloric acid gas yielded crystals of eudesmene dihydrochloride melting at 75-76° (see this Journal, Vol. LIX (1925), p. 147).

1.3318 grams in 10 c.c. chloroform gave a reading of $+ 4.5° = [a]_D^{20°} + 33.8°$. There is thus no doubt of the identity of this constituent with eudesmol, which is confirmed by the result obtained by acetylation of the crude oil.

Determination of other stearoptene of yellow colour.— The yellow crystalline solid insoluble in petroleum ether (after removal of the eudesmol), was purified from boiling ethyl alcohol, from which it separated in primrose-yellow coloured needles of melting point 103½-104°; yield 2.5 grams. This constituent was found to be identical with a body, thought to be a phenol ether, isolated from the essential oils of *Baeckea crenulata* and *Darwinia grandiflora* by the author and F. R. Morrison in 1922 (see Vol. LVI. (1922), pp. 87-89). It possessed a molecular formula of $C_{18}H_{18}O_4$, and showed the presence of two methoxy groups.

It is worthy of note that although three separate collections were made of the plant material over a period of three years from the same locality, yet this constituent was only detected in the first consignment, the last two showing no trace of its presence.

Determination of unidentified phenolic bodies.—All three lots of oil showed the presence of phenolic constituents on washing with 8% sodium hydroxide solution, the first yielded 1.4%, whilst the last two contained only 0.5%. They all gave reddish-brown colourations with ferric chloride in alcoholic solution, but their identity could not be established.

Determination of valerianic acid ester.—The oils obtained from the last two distillations, after removal of the phenolic constituents, were treated with alcoholic potash solution to decompose the small quantity of ester present. A volatile acid in small quantity was separated from the potash salts and found to consist mainly of valerianic acid; 0.0340 g. of silver salt gave 0.0179 g. silver on ignition = 52.64% silver. The silver salt of valerianic acid requires 51.68% silver.

The alcohol with which the acid was combined could not be separated or identified. It appeared to be concentrated in the very small fractions of distillates boiling between 70 and 120° at 10 mm. These fractions on treatment with napthylisocyanate yielded small amounts of napthylurethanes melting at 115-116°.

In conclusion, I have to express my thanks to Mr. E. Cheel, of the National Herbarium, Sydney, for the botanical identification of the material distilled, and to Mr. F. R. Morrison, A.S.T.C., A.A.C.I., Assistant Economic Chemist, for much assistance in the investigation.

THE TANNINS OF THE BLACK CYPRESS PINE
(*CALLITRIS CALCARATA* R.Br.)
AND THEIR DISTRIBUTION IN THE BARK.

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(With Plates XVII-XVIII.)

The Black Cypress Pine (*Callitris calcarata,* R.Br.),
occurs over a very wide area of the inland portions of the
Eastern States of Australia, and in a few localities it even
extends as far as the coast. In this paper, it is proposed to
deal with the bark, which is an important tannin-bearing
material, the work thus being a continuation of that
commenced on the Acacias.* The high tannin content
of this bark was first pointed out by Baker and Smith,††
in their exhaustive research on the pines of Australia; its
anatomical structure was also described. This was
followed by two papers from the Technical College Tanning
School,† which dealt principally with the leather-forming
properties, and gave qualitative tests of the bark and
tannins.

A satisfactory extraction of pine bark on a commercial

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* Notes on Wattle Barks, Part I., Welch, McGlynn & Coombs.
Proceedings, Royal Society, N.S.W., 1928.

†† Pines of Australia.

† Coombs, Comparative Sole-leather Tests with Australian
Pine Barks. Collegium (London), September, 1916.

Coombs and Dettman, Notes on Australian Pine Bark. Jour.
Soc. Chem. Ind. 1914.

scale was found, however, to be difficult—in this respect differing considerably from the Acacias. It was, therefore, considered necessary to make a more complete examination of the structure of the bark than had hitherto been done, and to compare it with that of Acacia bark, and also to study the actual distribution of the tannin throughout the tissues. Furthermore, it was essential to determine what was the actual cause of the resistance to the penetration of water into the bark, since the ease of extraction depends largely on two factors, namely, the solubility of the tannin, and the ease of water penetration.

Bark Structure.—The mature bark* of *Callitris calcarata* consists entirely of secondary phloem, the outer cortical tissues being lost at a comparatively early stage in the growth of the tree. A section of a twig a few mm. in diameter shows practically the same structure outside the cambium as occurs in the bark of a large tree. Cortical resin passages are replaced by those in the phloem, and the more or less isolated first formed bast fibres are replaced by more regular rows of radially compressed thick walled cells. As pointed out by Baker and Smith, the secondary phloem consists of concentric rows of bast fibres, one cell in thickness, interrupted by uniseriate medullary rays; between the bast fibres are normally three rows of cells, the middle row consisting of phloem parenchyma, and the two outer rows of sieve tubes. (Fig. 3.) The regularity of this arrangement in the Cupressineae is mentioned by De Bary.†

At a distance of about 4 mm. from the cambium in the mature bark there occurs an inner peridermal zone, 3-8 rows of cells in thickness, extending completely round the tree and

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* The word "bark" is used to denote all tissues outside the cambium.

† De Bary, Comparative Anatomy of Phanerogams and Ferns. English Translation, Oxford, 1884.

separating the inner living from the outer dead portion. Between this inner periderm and the outside of the bark there are a number of earlier formed peridermal layers at intervals of from 225μ to 1200μ. The cells of the periderm are thin-walled, and show a very marked coloration when treated with a fresh alcoholic solution of chlorophyll, thus indicating the presence of suberisation. The cells are compressed radially, and measure about 45μ x 8μ transversely, and 40μ in length.

The position of the innermost periderm can be easily determined by cutting the fresh bark transversely, when the living portion nearest to the cambium is seen to be white, altering to pink towards the outside. The dead tissues are reddish brown, the line of demarcation from the inner zone being sharply defined, becoming a dirty greyish brown towards the periphery.

The bast fibre cells are important in that their excessive development in a bark must naturally increase the amount of insoluble non-tannins, and correspondingly lower the percentage of tannin. Moreover, they have a direct effect on the difficulty or otherwise of grinding the bark. In the Cypress barks, however, they do not possess the same importance in this direction, as they do in the Wattle barks, where the fibres are grouped into large zones (c.f. Welch, McGlynn and Coombs, l.c.). In *C. calcarata* the cells are flattened in a radial direction (Fig. 3), the average size being 10μ x 40μ x 2000μ in length. The walls are always heavily lignified, the lumen being reduced to a narrow slit. Although near the cambium the radial walls are usually in contact, towards the outer part of the living secondary phloem the cells are often more or less isolated, due to the subsequent increase in circumference of the bark. The degree of separation varies in different barks, but should have the effect of making them easier to grind.

The sieve tubes are normally very much compressed radially within 0.5 mm. of the cambium. In no case was tannin or starch detected in them, and they are apparently of little direct importance in their influence on the actual amount of tannin yielded on extraction. In Fig. 4 they can be seen as more or less compressed rows of cells, usually empty, on either side of the phloem parenchyma, which possesses dark contents. The sieve tubes measure $6-18\mu$ radially and $20-40\mu$ tangentially, and near the cambium differ little in size or shape from the phloem parenchyma when seen in transverse section. The most important tannin-bearing tissue in the bark is the phloem parenchyma, more especially after enlargement occurs towards the inner peridermal layer (Fig. 2). The section illustrated was cut from a portion of the bark treated with potassium bichromate, which precipitates the tannin in an insoluble form, and has proved the best reagent for the study of the tannin distribution.*

It will be noticed that about half way between the cambium and the innermost periderm, the parenchyma cells undergo a very considerable increase in size: Thus, whereas a typical cell near the cambium measures 40μ x 8μ, near the inner periderm the dimensions are 110μ x 30μ. The increase in the size of these cells can be more clearly seen in Fig. 1, the tannin having been dissolved out, leaving the cell walls. Outside the periderm (Fig. 2), there is an apparent decrease in the tannin contents of the cells, but this is evidently due to the breaking away of portions of the cell contents during sectioning. The most striking feature of this section is the almost complete absence of tannin near the cambium, and the gradual increase in the tannin (seen as black masses in the illustration), till a maximum is

* Lloyd. The Occurrence and Function of Tannin in the Living Cell. Trans. Roy. Soc., Canada, 1922.

reached near the innermost peridermal zone. A more highly magnified transverse section, about midway between the cambium and the inner periderm, which has been treated with potassium bichromate (Fig. 4), clearly shows the regularly arranged phloem parenchyma cells, with their dark contents.

This gradual tannin increase outwards is in accord with what was found to occur in the Acacia barks, where practically the whole bark is analogous to the innermost living part of the Cypress barks. There is nothing in the bark of *Acacia mollissima* to correspond to the outer dead secondary phloem tissues which form the greater portion of the bark of *Callitris calcarata*. Thus in the Acacia bark, a considerable amount of tannin is present in the primary and secondary cortical tissues, and in the broad fan-shaped medullary rays, whereas in the Cypress barks, the cortical tissues are lacking, and the medullary rays are narrow and uniseriate. Although tannin is present in many of the medullary ray cells, it is not always so (c.f. Figs. 2-4), and they cannot be regarded as an important tannin-bearing tissue.

One of the most characteristic features of the Cypress barks is the very large development of resin passages in the phloem. They occur in more or less concentric rings (Fig. 2), and measure about 120μ in diameter, minimum $= 60\mu$, maximum $= 250\mu$, anastomosing freely in a tangential plane, but rarely radially. The contents of the innermost ducts are fluid- in fresh bark, clear viscous drops being exuded on a cut surface; those of the outer ducts are amorphous, non-fluid and resinous, appearing microscopically as irregular, angular, cracked fragments. The alteration in the physical character is due possibly either to the loss of the more volatile constituents of the oleo-resin or to oxidation or both. The ducts are readily observed

macroscopically in a transverse cut of the outer bark as white concentric rings. A well-defined epithelial layer surrounds each duct, and it is interesting to note that microchemical reactions show undoubtedly the presence of a high tannin concentration in these cells (Fig. 4), although no evidence of it has been found in the ducts themselves. Haas and Hill * state that it has been found that the amount of tannin varies inversely in *Pinus* as the resin content. Although no determinations have been made in the Callitris barks to ascertain whether a similar variation occurs, one would hardly expect to find much seasonal alteration in the whole bark, since the portion which preponderates and which contains a considerable amount of resin is non-living, and cannot alter except by decomposition. Nevertheless, it seems possible that there is a close relationship between tannin and resins since tannin is so prominent in the epithelial cells. The solubility of the contents of the ducts in alcohol is unchanged by the loss of the more fluid constituents; in all cases the resins readily dissolve in that solvent.

A microscopic examination of the bark also shows the presence of a large amount of starch in the phloem parenchyma, the medullary rays and the epithelial cells of the inner living zone of bark (Fig. 4). Peacock† has pointed out that in *Heuchera americana* tannin is most abundant in October, and least in May, whereas starch reaches a maximum in March. In the Callitris barks, no seasonal determination of starch has been made, but it is significant that starch occurs only in those cells in which tannin is found. The grains can be seen in Fig. 3 as small rounded masses (measuring about 5μ in diameter); in the

* Hass & Hill. Chemistry of Plant Products, Longmans Green, 1921.
† Peacock. American Jour. Pharmacy, 1891, p. 172.

cells in which tannin is most evident the grains are often
closely packed.   In no case were starch grains found
outside the innermost periderm, and it is evident that it is
converted to some other carbohydrate, or broken down
either just prior to the formation of the corky layers, or
utilised by the dying cells after their isolation by the
periderm.   Since starch is a carbohydrate food storage
body, one would expect to find seasonal variation, probably
reaching a maximum in the winter. The specimens collected
at Dubbo in June certainly showed abundant starch when
examined microscopically.

If thin sections of the fresh inner bark be transferred to
water, solution of the tannin is practically instantaneous,
and subsequent treatment with potassium bichromate or
ferric chloride shows no indication of tannin in the cells.
A few scattered parenchymatous cells near the periderm,
however, possess yellow contents which are insoluble in
cold water, but which darken when treated with solutions
of iron salts.   The contents of the cells of the outer bark
are in general, progressively less soluble in cold water
towards the outside, with a change in colour to a deep
brown.   The contents of the outermost cells are com-
pletely insoluble even in boiling water or alcohol, and this
also applies to scattered cells, even near the innermost
periderm.   The contents of these cells are clear and some-
what granular, amorphous, reddish brown, and often with
irregular cracks or markings.   In a typical bark in which
the inner living portion is 4.5 mm. in thickness, the in-
soluble masses are comparatively rare in the 3 mm. of dead
tissue adjacent to the innermost periderm; then in the
outer portion which varies considerably in thickness from
3 mm. to 30 mm. on account of the furrowed nature of the
bark, there is a gradual increase in the insolubility of the
cell contents.   It seems, therefore, that there is a gradual

alteration of the cold-water-soluble colourless tannins to a cold-water-soluble red tannin, then to a hot-water-soluble red tannin, and finally to a red insoluble phlobaphene. Practically all the insoluble cell contents are darkened with ferric chloride, but isolated cells show little or no alteration. When a bark section is treated with ferric chloride, there is an indication of tannin in the cell walls, but this is evidently only due to adsorption of the tannin brought into solution during the examination, since no tannin was shown in the walls when the sections were treated directly with potassium bichromate.

Extraction.—It is not yet suggested that the difference in the ease of extraction of pine and wattle barks is due to the variation of the solubility of the tannin. All barks used for the extraction of tannin are usually broken up into small particles before the introduction into the extraction vats. The smaller the particles, the easier the extraction, provided that the water can pass freely through the mass and wet each particle. It should be noted that although a plant is obtainable for dealing with powdered bark, without exception all Australian tanneries have plants for the extraction of bark in coarse lumps, and these plants, whilst quite satisfactory for the treatment of wattle bark, are apparently unsuitable for pine.

The factor of water-penetration was dealt with by a series of experiments with wattle and pine barks. The first experiment was the extraction of soluble matter from the bark with water at ordinary summer temperature, and also at 50° C. Working under these conditions, one portion of the bark was ground to powder, and another portion was crushed to pieces, as used in the tannery. This gave two comparative tests with fine and coarse bark. If the extraction results were equal, it would be considered as evidence that the forces opposing water penetration were

negligible, but if a considerable difference were shown between the two results, it would indicate that the water penetration and the subsequent diffusion of the tannin from the bark were retarded by unknown factors.

Apparently water passes freely into the bast cells, and it has been noted that the tannin diffuses just as freely from these cells. The size of the cells is approximately 1/600in. x 1/3000in., and 1,500,000 would be required to cover one square inch, so that the grinding of the bark could not be expected to rupture all the cells. Ruptures may occur as a result of contraction of the cell walls after the bark has been dried, but there is no evidence to show that this does take place. Therefore, the theory at present must be one that assumes that the tannin is removed by diffusion through the undamaged walls of the cells. After that the tannin could be expected to choose the path of least resistance and diffuse outwards to places of lower concentration.

The results obtained by extracting coarse and fine wattle bark showed that the fine bark at ordinary temperatures gave up 7.3%, and at 50° C. 2.4% more soluble matter than the coarse. These figures are taken as an indication that the forces opposing water penetration are small so far as wattle bark is concerned.

Different results were obtained with the pine bark, and the experiment was carried out in the following manner: Equal quantities of fine and coarse bark were treated with water which was removed as tan-liquor. This was repeated until five liquors were drawn off the bark. Each liquor was analysed and the sum of the results is shown below. For further details regarding this experiment see "Extraction of Tannin from Wattle Bark."*

* Extraction of Tannin from Wattle Bark. New South Wales Tanning Committee, Technical Gazette, Sydney, Vol. 12, pt. 2, 1922.

Extraction Results.—Pine Bark.

	Ordinary temperature.		Temperature 50°C.	
	Coarse.	Fine.	Coarse.	Fine.
Tannin	19.18 grms.	29.42 grms.	25.34 grms.	33.89 grms.
Non-tannin ..	12.88 „	13.41 „	13.58 „	14.40 „
Total Solubles ..	32.06 „	42.83 „	38.92 „	48.29 „

The maximum amounts of the total tannins and non-tannins extracted were 70 and 83 per cent. respectively.

These returns show that the fine bark at ordinary temperature gave up 33.5%, and at a temperature of 50°, 24% more soluble matter than the coarse bark. This certainly indicates that water penetration into pine bark and the subsequent diffusion of the soluble substance is retarded to a considerable extent, especially when compared with wattle bark.

The total solubles are made up of tannins and non-tannins, and it is important to note that the difference in the above figures is due more to the variation in the amounts of the tannins than to the non-tannins. The latter only show a difference in favour of fine bark of 4.1% at ordinary temperature and 6% at 50° C., while the corresponding figures for the tannin are 53.4 and 33.7%. If the smallest particles of the bark used are constant as regards structure and cell contents, then these figures for tannins and soluble non-tannins would indicate that the reason for a greater and more regular extraction of the total non-tannins in comparison with the total tannin must be due to the tannin being more difficult to bring into solution, or that for certain reasons its diffusion from the bark is retarded to a considerable extent. Further work has shown that the smallest particles are not constant as regards cell contents, and, moreover, the structure of the inner living bark differs from the outer portion, due to the absence of the suberised peridermal layers. These occur-

at frequent intervals of from 0.25 mm. to 1 mm.; whereas the pieces of coarsely ground bark often measure up to 10 mm. x 5 mm. x 5 mm.; therefore the opportunities for water penetration in these large pieces are considerably reduced, and can only occur tangentially between the impervious cell layers. It is important to note that in the outer portion, the soluble non-tannins are reduced to a minimum, as will be shown later by analyses, whereas in the inner bark zone which is devoid of impervious layers, and into which water can readily penetrate, the soluble non-tannins reach a maximum. It is easy to understand, therefore, that an extraction of coarse or fine bark removes the soluble non-tannins practically with the same ease; whilst the tannin, which is distributed throughout the whole bark, is obviously less easily removed from the outer portion, apart from any variation in its actual solubility.

The complete removal of the tannin from the bark by the usual methods can only be accomplished with the aid of hot water, but no substance is returned as tannin unless it be soluble in water at 15° to 20°. Catechol tannins which have changed to the insoluble state are classed as phlobaphenes. These phlobaphenes are rarely found in the living secondary phloem, but they undoubtedly exist in the ross, or outer layers, especially in the pine bark.

If ordinary ground bark be covered with water, that portion which is not absorbed soon shows signs that some of the tannin has passed into solution and is diffusing from the bark. If the temperature be kept constant at about 20°, the amount of tannin diffusing from the bark after 24 hours' exposure reaches a very low figure, which can only be increased again at the same temperature by lowering the tannin concentration of the surrounding liquor. This change in concentration is brought about by removing the old and replacing it with a weaker liquor or water.

When the diffusion of tannin from the bark practically ceases it could be assumed that the tannin concentration in the bark structure and surrounding liquor is the same. At this stage if the tannin be all alike as regards its solubility, and omitting adsorption, it should be possible to calculate the total tannin originally in the bark from the concentration and volume of the surrounding liquor, when the volume of liquor retained by the bark is also known. This means that under these conditions the total tannin in the bark could be estimated from the tannin found in a known proportion of the total volume of liquor. This known proportion can only come from the liquor surrounding the bark, and a few experiments have shown that its tannin values are always too low even if the total tannin be calculated as that amount extracted at 20°. When the total tannin is considered as that amount soluble at 20°, but extracted at the usual high temperatures, then this figure is very much too low.

The specific surface of the bark must reach a fairly high figure, as noted by the size of the cells, and therefore adsorption is a factor to be considered when extracting tannin from barks, etc. That the amount of tannin found in the liquor which can be drained away from the bark is always too low to permit a correct volumetric calculation may be largely due to adsorption, and the fact that complete extraction requires water at a high temperature suggests that the theory that a rise in temperature reduces the adsorption power of charcoal may be applied in this case.

The solubility of the tannins must be considered here, and it should be noted that the high temperatures 80° to 100° required for the extraction of tannin soluble in water at 20° have always been considered necessary for a complete extraction. Proctor and Parker[*] carried out certain

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[*] Proctor and Parker. Jour. Soc. Chem. Ind., 1895, p. 635.

experiments which gave results obtained from various tanning materials when extraction was carried out at various temperatures ranging from 15° to 100°.

They showed an optimum temperature for extraction for each material at which more tannin could be extracted than at any other, though a small additional amount could be obtained by boiling the extracted residue.

If we examine their optimum figure for wattle bark we find that the maximum percentage of tannin extracted was at 70° to 80°, with only a 6% loss for extraction at a higher temperature ranging between 90° to 100° C. This result and others that are more prominent, show that tannin is certainly destroyed at the higher temperatures, and one might say that a satisfactory and workable extraction can only be obtained by using a high temperature, but there will always be a loss of tannin which will reach a maximum for any material when the tannin that can be extracted at the lower temperatures is exposed to the highest temperature, and a minimum when these tannins which are extracted at the lower temperatures are removed and not exposed to the highest temperature.

This optimum temperature, then, is a point where the extra amount of tannin extracted by an increase in temperature just exceeds the amount destroyed when the temperature remains constant for each extraction.

The destruction of catechol tannins by heat is generally recognised, but apparently the pine tannins as they exist in the bark are more sensitive to this factor than the wattle tannins. Extraction experiments with pine bark on a practical scale have shown that the tannin cannot be satisfactorily removed from the usual coarse pieces at a low temperature.

When the higher temperatures were reached for the same work, the extraction results were still too low when compared with results obtained from wattle bark under similar conditions. Analyses of the spent bark and liquors containing extracted tannin show that tannin was destroyed in the pine bark at the higher temperatures.

This result might be described as a want of stability of the pine tannins at a high temperature—tannins changing to the insoluble phlobaphenes—but further experiments have shown that there are other factors.

Proctor and Parker's research shows that tannin is destroyed over a period of a few hours by using a high temperature, and analytical figures are now given for a comparative experiment with four solutions of pine tannin made up from one pine bark liquor. The tannin concentrations were the same for these solutions, but two were exposed on a water bath for four hours at a temperature of 98°. This experiment was expected to show if these pine tannins were affected by heat under conditions of temperature comparable with those prevailing when extracting for analysis. The tannins used for this experiment were extracted at temperatures not exceeding 50°.

	Normal.			4 hrs. at 98°C.	
	1	2		3	4
Tannin	4.40	4.42	..	4.34	4.36
Non-Tannin..	3.80	3.77	..	3.87	3.83
Total Solubles.. ..	8.20	8.19	..	8.21	8.19

These results show that pine tannin extracted at a low temperature and then exposed to a temperature of 98° for three hours, only lost 0.93 per cent. of the total tannin. This seems to show that these tannins are not sensitive to high temperatures, and such a result is not in agreement

with the theory that the large amount of tannin destroyed during the leaching of this bark is due to high temperatures.

One factor in the destruction of tannins during an extraction process might be starch. Microscopical examination has shown that there is a considerable amount of starch in the inner portion of the bark. An unfiltered starch solution, 1 grm. per litre, when added to a solution of pine tannins, gives a cloudy liquor which soon deposits insolubles, and the filtered starch solution when added to a filtered solution of pine tannins, analytical strength, gives a cloudy liquor which deposits overnight.

When a solution of pine tannins is mixed with a starch solution the resulting cloudy solution responds to heating, and the iodine test in a manner similar to that described below.

This starch factor was tested by making up a solution containing a certain amount of tannin and 0.5 grm. of starch, previously treated with water and brought to 100°, then cooled down to 18° and added to the tannin. The solution was then made up to a litre and analysed. For comparative purposes another solution containing the same amount of tannin per litre and no starch was also analysed. The tannins used were obtained from 250 c.c. of a pine liquor extracted at a temperature ranging from 20° to 50°. This pine liquor was a bright, clear solution, and the same volume was used for each test. The following are the results from the duplicate tests:—

	No. 1. With Starch.	No. 2. With Starch.	No. 3. Without Starch.	No. 4 Without Starch.
Tannin	3.166 grm.	3.186 grm.	3.607 grm.	3.589 grm.
Non-tannin ..	2.544 „	2.520 „	2.481 „	2.515 „
Total Soluble ..	5.710 „	5.706 „	6.088 „	6.104

The solutions receiving starch show a loss of 11.7% tannin and a non-tannin increase of 1.4%. These starch and tannin mixtures responded to the iodine test, but not after filtering, which indicates that all the starch was precipitated with that portion of the lost tannins shown above. The tannin and starch combination behaved like tannins that remain as suspended matter in a cold solution, but dissolve in sufficient quantity to give a much brighter solution at the higher temperatures.

From the work done on these barks we find that a considerable amount of suspended matter remains in the solution extracted at 100°. This suspended matter was first considered to consist of substances like tannin that are only soluble in hot water, but after our tests with starch we consider that it is possible that a large portion of it is the insoluble tannin and starch combination.

If other tanning materials contain starch in like quantities, then it is possible that a certain proportion of the tannin destroyed, as shown by Procter and Parker's figures with optimum temperatures, could be attributed to starch. Starch granules would not be expected to destroy tannin when extraction proceeds at a low temperature, but this would be reversed at high temperatures suitable for dissolving the starch.

The most important factor noted as far as water penetration is concerned, is that the greater portion of the tannin is in the outer bark, where we find barriers set up by corky layers, which prevent water penetration in certain directions.

Whilst dealing with the question of resistance to water penetration, another factor to be considered is the resinous condition of these barks. These resins occur in passages, as already pointed out, all through the structure, and while the

crushed bark may be smeared with them to a certain extent, there is nothing to show that they are the cause of any great opposition to the penetration of water, although as mentioned in the description of the anatomical structure of the bark, the resinous contents of the ducts are in close proximity to the tannin bearing epithelial cells.

As only a portion of the tannin is extracted at a low temperature, it might be considered that this result is related to a difference in the cell walls, whereby tannin is extracted from some cells with cold water and other cells only give up their tannin when hot water is used. Such an assumption is, however, scarcely warranted, since the tannin is only contained in thin walled cells, which would offer a minimum of resistance to the penetration of water, but which would scarcely show a variable penetration factor at any one temperature.

Bark Layers.—It has been shown by a microscopical examination of the bark that the phloem cells cut off by the cambium, and their contents, are subjected to certain changes as they become older. These changes, as far as the tannin content of the cells is concerned, have been followed by making analyses of certain layers of the bark, it being split longitudinally into three divisions. Thus the innermost living portion was stripped off, and the remainder was again divided into two by the removal of the outermost ross. These layers were numbered in turn, 1, 2, and 3, No. 1 being the innermost, i.e., nearest the cambium. The ross which was removed corresponded to that usually removed by bark strippers when working on a commercial scale, and consists of cells more or less disintegrated on account of exposure to weather.

Samples taken at the end of December, at Dunedoo, N.S.W., three feet from ground.

No. 1 *Tree.* 50 ft. high, 12 inches diameter.

Layer.	Weight.		Tannin.	Non-tannin.	Insoluble.	Water.	Total.
No. 1	107 grm.	..	19.64	19.47	49.39	11.5	100.0
No. 2	1013.7 „	..	21.07	4.8	62.63	11.5	100.0
No. 3	125.4 „	..	3.98	3.74	80.78	11.5	100.0

No. 2 *Tree.* 36 ft. high, 7 inches diameter.

No. 1	106.5 „	..	20.28	17.68	50.54	11.5	100.0
No. 2	616.5 „	..	20.48	4.43	63.59	11.5	100.0
No. 3	93.0 „	..	2.71	3.57	82.22	11.5	100.0

No. 3 *Tree.* 40 ft. high, 12 inches diameter.

No. 1	153.5 „	..	28.79	15.56	44.15	11.5	100.0
No. 2	368.1 „	..	24.42	4.36	59.72	11.5	100.0
No. 3	333.9 „	..	6.86	2.57	79.07	11.5	100.0

From an examination of these figures it will be seen that the outer portion of the bark has lost, through exposure or due to alteration to an insoluble form, the greater portion of its tannin.

This layer, which is always a dirty grey in colour, can be separated and scraped off without difficulty, using as a guide the fact that as the useful tannin bearing zone is approached, the colour changes to a reddish brown. It is, therefore, suggested that when stripping for commercial purposes this useless outer portion should always be removed, since there is little loss of tannin. A similar portion is removed in America when stripping the Hemlock Bark *Tsuga canadensis.*

The greatest proportion of the bark by weight is that included under No. 2, containing water solubles consisting of red tannins and a small amount of non-tannins. The inner portion, No. 1, contains light coloured tannins almost similar in quantity to those found in No. 2, but with a much higher percentage of soluble non-tannins. Since the No. 1 zone is the living part of the bark, one would expect to find the majority of soluble carbohydrates and nitrogenous materials within this portion, and this is borne out by the analyses.

TANNIN VALUES OF PINE BARK SAMPLES.

Dunedoo, N.S.W., December, 1920.

Samples taken about 2 feet from ground.

	Diameter of tree.	Tannin.	Non-tannin.	Insolubles.	Water.
No. 1 ..	15 inches	21.34	6.62	60.54	11.50
„ 2 ..	12 „	20.93	6.21	61.36	11.50
„ 3 ..	12 „	22.63	9.09	56.78	11.50
„ 4 ..	12 „	25.41	6.90	56.19	11.50
„ 5 ..	9 „	18.24	18.14	62.12	11.50
„ 6 ..	7 „	20.45	6.38	61.67	11.50
„ 7 ..	5 „	34.11	8.27	46.12	11.50
„ 8 ..	4 „	26.41	7.52	54.57	11.50
„ 9 ..	4 „	36.37	10.18	41.95	11.50
„ 10 ..	3 „	18.58	7.25	62.67	11.50
„ 11 ..	3 „	32.27	11.46	44.77	11.50
„ 12 ..	1½ „	26.15	10.20	52.15	11.50

Cookamidgera, N.S.W., June, 1923.

Samples taken 2 feet from ground.

	Diameter of tree.	Tannin.	Non-tannin.	Insolubles.	Water.
No. 1 ..	—	21.25	6.30	60.95	11.50
„ 2 ..	5 inches	27.28	9.18	52.04	11.50
„ 3 ..	11 „	22.19	5.53	60.78	11.50
„ 4 ..	5 „	19.57	6.38	62.55	11.50
„ 5 ..	6 „	36.29	7.92	44.29	11.50
„ 6 ..	—	21.31	7.24	59.95	11.50
„ 7 ..	8 „	26.12	5.40	56.98	11.50
„ 8 ..	14 „	32.55	5.22	50.73	11.50
„ 9 ..	10 „	33.67	7.09	47.74	11.50

These analyses were made to ascertain whether the diameter of the tree has any effect on the tannin content. In any one locality, diameter might be considered to vary approximately as the age of the tree, provided ecological conditions were similar.

It seems that in general the highest tannin content obtains in the smaller trees, although exceptions to this occur. From the results obtained from the Cookamidgera samples it seems that the highest yields are from trees

growing on level ground at the foot of the ridges or on the slopes.

It is obvious that many more analyses are necessary before any definite conclusions can be made, but our experience shows that the best results are obtained from well grown trees, and are probably independent of actual elevation.

The conditions of growth are important, e.g., whether the trees are in close or open stands, more especially since the closer stand produces fewer lateral branches, and is easier to strip; secondly the consequent greater height increment would produce trees yielding a greater amount of bark.

Comparative Tannin Value of Bark taken from bottom and top of Tree.

Samples collected at Dunedoo, N.S.W., December, 1920:—

No. 1 Tree, 50 feet.

Samples taken as follows:—

    A at 2 ft. from ground—diameter 12 inches
    B at 13 ft. „   „   „   8 „
    C at 23 ft. „   „   „   5 „

	Tannin.	Non-tannin.	Insolubles.	Water.
A	20.93	6.21	61.36	11.50
B	21.38	8.74	58.36	11.50
C .. .	20.21	9.71	58.58	11.50

No. 2 Tree, 30 feet.

		Tannin.	Non-tannin.	Insolubles.	Water.
A at 2ft.:	diam. 7″	20.45	6.38	61.67	11.50
B at 10ft.:	„ 5″	19.76	7.82	60.92	11.50
C at 18ft.:	„ 4″	19.70	8.46	60.84	11.50

No. 3 Tree, 50 feet.

		Tannin.	Non-tannin.	Insolubles.	Water.
A at 3ft.;	diam. 12″	22.63	9.09	57.4	11.50
B at 40ft.:	„ 4½″	16.87	11.08	60.56	11.50

No. 4 Tree, 40 feet.

		Tannin.	Non-tannin.	Insolubles.	Water.
A at 3ft.:	diam. 9″	18.24	8.14	62.13	11.50
B at 30ft.:	„ 4″	19.75	12.10	58.84	11.50

These analyses were made to determine whether the percentage of tannin in the bark varied towards the top of the tree.

With the exception of No. 3 in which there is a considerable decrease in the tannin content at the higher elevation, there is apparently little variation in the figures obtained. This is in very marked contrast to the Acacia barks, in which there is a very definite decrease as the bark becomes thinner, but is readily explained when it is understood that practically the whole of the Acacia bark consists of living cells of the secondary phloem and cortex, and the maximum tannin bearing zone is towards the outside; in the Callitris, however, the maximum tannin bearing zone is within a few mm. of the cambium (i.e., in the outer part of the living secondary phloem within the innermost periderm), outside which there is a progressive decrease in the soluble tannin.

Since this inner zone is only a comparatively small percentage of the whole bark, and does not vary greatly in thickness along the tree, it is evident that it cannot affect to any great extent the result obtained by analysing the complete bark.

In every case there is an increase in the soluble nontannin, and a corresponding decrease in the "insolubles" towards the upper part of the tree. This would be accounted for by the fact that the proportion of inner living bark to dead tissues is highest in the uppermost portions, and it is principally in the living secondary phloem that the soluble non-tannins are present.

Commercial Samples.

The following results are important since they indicate the actual results likely to be obtained when stripping on a large scale.

	Tannin.	Non-tannin.	Insolubles.	Water.
(1) From a ten ton lot	23.34	9.21	55.95	11.5
(2) Sample taken from 10 cwt. of bark. Trees above 8in. diam.	25.29	8.53	54.68	11.5
(3) Sample taken from 10 cwt. of bark	25,36	8.27	54.87	11.5

Summary.—*Callitris calcarata* yields an important tannin-bearing bark available in large quantities. The bark or secondary phloem consists of two main portions— an inner living zone about 4 mm. in thickness, and an outer non-living zone, separated by a narrow periderm. These periderms are a few cells in thickness, and occur at intervals of from 225-1,200μ throughout the outer zone.

The secondary phloem consists of very regularly arranged layers of bast fibres, sieve tubes and phloem parenchyma. At irregular intervals are more or less concentric rings of tangentially anastomosing resin passages.

Tannin occurs principally in the phloem parenchyma, in the medullary ray cells, and in the epithelial cells lining the resin passages. It was not observed in the bast fibres or sieve tubes. The tannin is readily soluble in water in the inner living bark, but becomes progressively less soluble in the outer portion, finally becoming practically insoluble towards the outside; the cells being filled with a brownish amorphous phlobaphene-like body.

Starch grains were observed in the living cells of the inner zone in which tannin was present. No starch was found outside the innermost peridermal layer.

The extraction of the tannin on a practical scale gave results which showed that a considerable amount was destroyed. The reason for this destruction can be found by taking into consideration the methods of extraction for analysis. When the bark is ground to a fine powder, a large excess of water is used, and the temperature is con-

trolled so that only a small portion of the total tannin is exposed to higher temperatures. Working on a commercial scale, large particles of bark are used with a minimum amount of water and a longer exposure to high temperatures.

Experiments with fine and coarse bark particles showed that the resistance to water penetration and to tannin diffusion increases considerably with larger particles, in contradistinction to wattle. Therefore, for satisfactory commercial extraction, pine bark should be finely ground.

It is not considered that the presence of resin is a serious factor in the resistance to water penetration; rather is this due to the closely arranged impervious corky peridermal layers through which water cannot penetrate.

Pine barks are not sensitive to high temperatures, and some other factor must be sought to explain the loss of tannin in large scale extraction. It has been shown that starch is present, and this would be brought into solution at the high temperature used, and further, it has been proved that starch is able to destroy a considerable amount of tannin.

It is suggested, therefore, that since starch is extracted during the analytical process, prolonged exposure at a high temperature would bring about the removal of a greater amount of starch, and hence an increase in the amount of tannin destroyed.

The specific surface of the bark would reach a high figure, but further investigation is required to show what influence adsorption would have on the resistance offered to extraction. Possibly adsorption is responsible for the high temperature required for the satisfactory extraction of the bark.
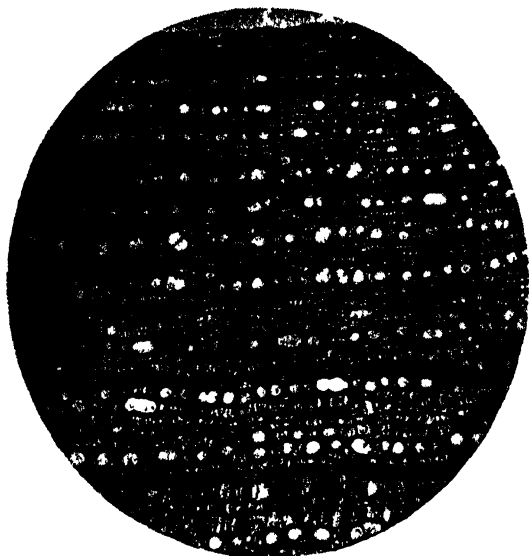
Fig. 1.
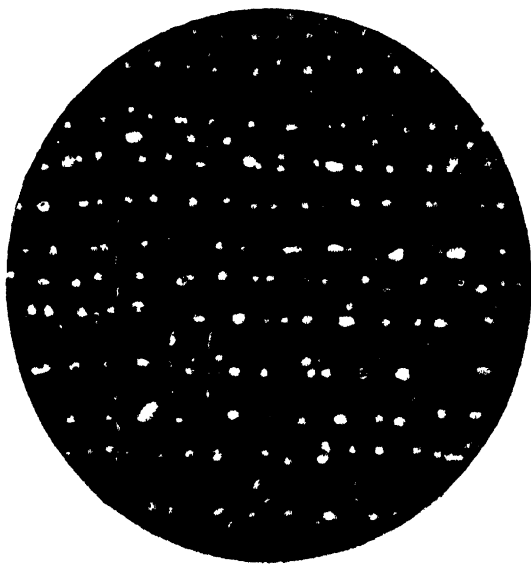
Fig. 2.
Callitris calcarata.

Analyses of different layers of the bark showed that the maximum tannin content occurred towards the outside of the inner zone, whereas the "soluble non-tannins" reached a maximum near the cambium. Outside the inner periderm there was a decrease in the tannin, which reached a minimum at the periphery. The tannins in the ross of pine bark, however, represent 60% of the total, and it is the predominating influence of these red tannins which give the distinctive features peculiar to a leather obtained with a straight pine tannage.

Analyses made on bark samples from different sized trees seem to show that the maximum tannin content is found in small, well-grown trees. There is practically no variation in the tannin content of the bark removed at different heights on the tree, in this respect differing considerably from wattle. Although analyses of individual barks have shown up to almost 37% tannin, the figure obtained from commercial samples is in the vicinity of 20-25% tannin.

In conclusion we wish to record our thanks to the Forestry Commission, N.S.W., Mr. A. R. Samuels, District Forester, Dubbo, and Messrs. Fitzpatrick and Greatrex for assistance in obtaining samples for investigation.

Explanation of Plates.
PLATE XVII.

Fig. 1. Transverse section of inner bark of *Callitris calcarata* R.Br. (cambium at top) after removal of the tannin, showing the regular structure. Near the bottom are portions of two concentric peridermal bands which occur at more or less regular intervals throughout the non-living secondary phloem. Numerous resin canals are clearly shown. The considerable increase in size of the phloem parenchyma cells can be traced from the cambium until they reach a maximum outside the second periderm. x 14.

Fig. 2. Transverse section of portion of bark of *Callitris calcarata* R.Br. (cambium at top) showing distribution of tannin.

Near the bottom of the microphotograph there is an apparent
marked difference in tannin content between the upper living
and the lower non-living zones. This is due to the fact that
the contents of many of the cells of the latter zone have been
broken away in sectioning. The tannin is seen to occur right
to the edges of the resin canals, which appear as rounded
openings. The verical clear marks are due to the non-occur-
rence of tannin in all cells of the medullary rays. It is evident
that comparatively little tannin occurs in the tissues nearest
the cambium. x 17

PLATE XVIII.

Fig. 3. Transverse section of portion of inner living second-
ary phloem of *Callitris calcarata* R.Br. The regular arrangement
of the alternating layers of bast fibres, sieve-tubes and phloem
parenchyma is apparent. The epithelial cells lining the resin
canals can be seen. At right angles to the bast fibre layers are
several uniseriate medullary rays. x 110

Fig. 4. Transverse section of portion of bark of *Callitris
calcarata* R Br., showing distribution of tannin, under a greater
magnification. No tannin is seen in the sieve-tubes or bast
fibres, and little in the medullary rays. The occurrence in the
phloem parenchyma and in the epithelial cells of the resin
canals is strongly marked. It is important to note the presence
of starch grains, seen as small rounded, almost clear bodies in
the tannin bearing cells. x 120
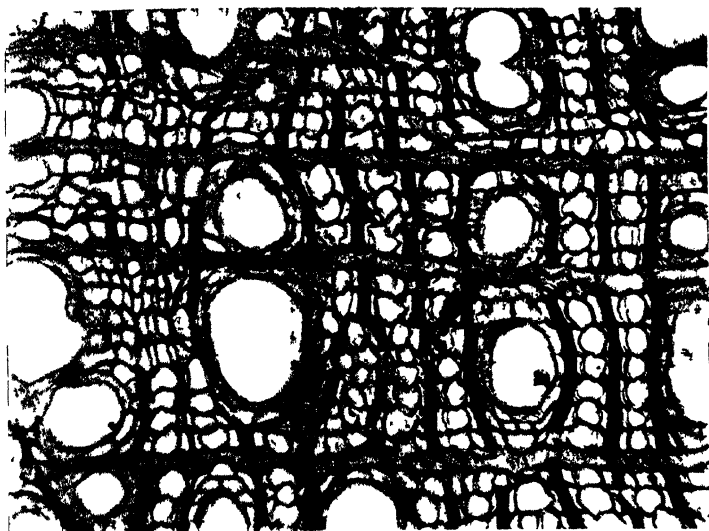
Fig 3
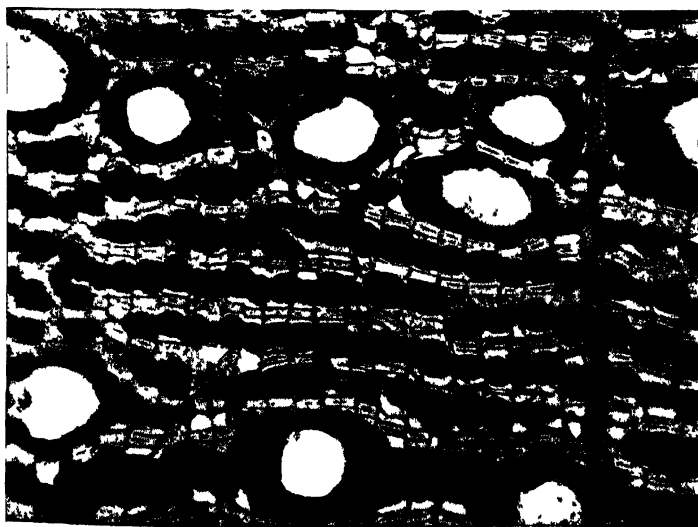
Fig. 4
Callitris calcarata.

ON THE OCCURRENCE OF WATER-WORN PEBBLES OF COAL IN THE UPPER COAL MEASURES AT RED HEAD, NEW SOUTH WALES.

By C. A. SUSSMILCH, F.G.S.

In his account of the Geology of the Hunter River District Coal Measures, Sir T. W. Edgeworth David[*] refers to the occurrence of water-worn pebbles of coal in a bed of conglomerate in the Upper Coal Measures at Red Head. The writer has recently, at the suggestion of Sir T. W. E. David, investigated this occurrence for the purpose of studying any bearing it might have upon possible earth movements, during the Upper Coal Measure Epoch.

The conglomerate in which the coal-pebbles are found occurs on the coast on the northern side of a prominent headland known as Red Head, some six miles to the south of Newcastle. Its position here is immediately above a coal-seam known as the Burwood Seam, and it forms a rock-bench only a few feet above sea-level. This stratum is really a coarse-grained sandstone containing occasional irregular lenticular patches of conglomerate; it is with these patches of conglomerate that the coal-pebbles are associated. The coal-pebbles themselves are from 1 to 3½ inches in diameter, are not very numerous, and are not

[*] The Geology of the Hunter River Coalfield by T. W. Edgeworth David, B.A., F.R.S., F.G.S., Memoirs of the Geological Survey of New South Wales, Geology No. 4, page 80, Department of Mines, Sydney, 1907.

easy to collect. In some of these pebbles the coal is quite
bright and lustrous, and one of those collected shows the
characteristic jointing of coal (cleat).

Chemical analyses of two of the larger coal-pebbles have
been made by Mr. Ralph Basden, and are given in the
table; the same analyst has also made an analysis (No. 4)
of a sample of coal collected from the Burwood Seam at
Red Head. In the table are given also a number of analyses
(No. 3 and Nos. 5-8), of other Hunter River District coals
for purposes of comparison; these have been taken from
the Coal Resources of New South Wales*. All the analyses
in the table have been re-calculated as ash-free coal, in
order to enable a better comparison to be made.

Analyses 1 and 2 show that the coal-pebbles consist of
anhydrous bituminous coals, thus showing that coal-making
processes had probably been completed before they had
been transported and water-worn; the presence of "cleat"
in the coal also supports this view. In his description of
these pebbles David suggested that they might have been
derived from the immediately underlying Burwood Seam,
but it seems quite impossible that the carbonaceous matter
of the Burwood Seam could have already been converted
into a true anhydrous bituminous coal at the time the
immediately overlying conglomerate was laid down. There
is no field evidence of any interruption of sedimentation
between the two beds at Red Head, and the time-interval
which could have occurred between the laying down of the
Burwood Seam and the overlying conglomerate must have
been very short.

By comparing the analyses of the coal-pebbles with those
of other coals in the table, it will be seen that coal-pebble
No. 1 is in composition practically identical with coal from

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* Coal Resources of New South Wales by E. F. Pittman,
Geological Survey of New South Wales, 1912.

the Greta Seam, which occurs in the Lower Coal Measures; its hydrocarbon percentage (ash-free analysis), is higher than that of the average analysis of Greta coal, but is not quite so high as a sample of Greta coal from the Central Greta Colliery (No. 8). There appears to be no reason, therefore, from the point of view of composition why this pebble might not have been derived from the Greta Seam. It is, of course, much higher in ash content than the average of Greta coal, but it is the impure bands of a coal-seam which are most likely to survive denudation and transportation.

Coal-pebble No. 2 is not so easy to place, as it is very low in hydrocarbons as compared with other Hunter River coals; the nearest comparison I can find is with an analysis of the Lower Rathluba Seam (No. 6), from the Middle or East Maitland Coal-measures. The exact source of origin for this No. 2 pebble must, for the present, be left undecided, but one would have expected that all of the coal pebbles, occurring as they do, so far as is known, with such a limited distribution both vertically and horizontally, would have had a common source of origin.

David has shown* that there is an unconformity between the Upper Coal Measures and the Upper Marine Series at Ellalong. It seems quite probable, therefore, that the Lower Coal Measures, and possibly also the East Maitland Coal Measures, were exposed and being denuded during the time that the Upper Coal Measures were being laid down, and that the coal-pebbles at Red Head were derived from this source.

In conclusion, it may be said, therefore, that it is highly improbable that these coal-pebbles could have been derived

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* The Geology of the Hunter River Coalfield by T. W. Edgeworth David, B.A., F.R.S., F.G.S., Memoirs of the Geological Survey of New South Wales, Geology No. 4, page 90, Department of Mines, Sydney, 1907.

from the underlying Burwood Seam in the Upper Coal
Measures, but that there is very strong evidence that one
of them at least and perhaps all of them, were derived from
the Lower Coal Measures. They, therefore, do not afford
evidence of any important crustal movement having taken
place during the course of the Upper Coal Measure Epoch;
but their nature and occurrence does suggest that the
Lower Coal Measures (and perhaps Middle Coal Measures),
had been folded before the Upper Coal Measures were laid
down, and were exposed to denudation during that epoch.

ANALYSES OF COALS.

No.	Samples.	Analyses.				Analyses Calculated ash-free.		
		Mois-ture	Vola-tile hydro-carbons	Fixed carbon	As	Mois-ture	Vola-tile hydro-carbons	Fixed car-bon
1.	Coal Pebble No. 1. ..	2.21	36.0	40.6	22.13	2.83	46.23	50.93
2.	„ „ No. 2. ..	1.70	23.6	44.7	30 00	2.44	33.71	63.85
3.	Newcastle Coal Measures —Average	2 01	36.01	53.27	8.91	2 2	39.54	58.34
4.	Burwood Seam — Red Head	1.66	32.2	47.64	18.5	2 03	39.51	58.45
5.	East Maitland Coal Measures—Average ..	1.88	35.71	53.77	9.64	2.08	39.52	58.4
6.	East Maitland Coal Measures — Lower L. Rathluba Seam	1 90	31.27	51.70	15.13	2 23	36.88	60.91
7.	Lower Coal Measures— Average	1.84	41.61	49.52	7.03	1.97	44 76	53.27
8.	Lower Coal Measures— Central Greta Colliery	1 26	46.70	47 01	6.96	1 32	49 17	49.51

SOME TERTIARY FORMATIONS ON THE SOUTH
COAST OF NEW SOUTH WALES.

WITH SPECIAL REFERENCE TO THE AGE AND ORIGIN
OF THE SO-CALLED "SILICA" ROCKS.

By IDA A. BROWN, B.Sc., *Demonstrator in Geology,
University of Sydney.*

(Communicated by Professor L. A. Cotton, D.Sc.)

(With Plate XIX.)

(Read before the Royal Society of New South Wales, Dec. 2, 1925.)

Introduction.

During the course of geological investigations on the
South Coast of New South Wales, the writer has had
occasion to examine certain formations, which appear to
be very much younger than the associated rocks.

Permo-Carboniferous rocks in this district are repre-
sented by outcrops of Upper Marine Beds for over fifty
miles south of the mouth of the Shoalhaven River. These
beds rest unconformably on older rocks, including phyllitic
slates, possibly as old as Ordovician, which outcrop for
many miles further south. Various igneous rocks have
been intruded into the sedimentary and metamorphic rocks,
at intervals along the coast.

A few miles to the south-east of Moruya, beds of sedi-
mentary rock rest partly on phyllitic slates and partly on
intrusive granite. Beds which appear to be identical with
these, outcrop in the Ulladulla-Milton District, and similar
formations are said to occur at intervals from Bodalla to
Jervis Bay. In a report on the soils of the South Coast,
Jensen [12], noted the occurrence of Tertiary drift near
Mogo, which is about 10 miles north of Moruya.

Sandstones, which are more recent than Permo-Carboniferous, have been reported from Kiama [7]. Their age is considered to be Tertiary or Post-Pleistocene.

Inland, Tertiary beds have been recognised at Nerriga and Wingello, at a height of about 2,350 feet above sea level [7]. Fossil leaves from the Wingello beds have been described by Deane [6], and the beds are believed to represent old river channels [15, 16], preserved under cappings of basalt, similar to the leads of the Kiandra [1] and the New England districts [2, 3, 4, 5].

Tertiary Rocks near Moruya.

South of Moruya a belt of arenaceous sedimentary rocks extends from Congo Point towards Coila, and possibly further south. The beds are known to occur over an area of at least six square miles, close to the present coast line, and up to a height not exceeding about 200 feet above sea level.

They consist of level-bedded sandstones, grits and conglomerates, which are somewhat loosely-compacted, and rest unconformably on phyllitic slates near Congo Point, and on weathered granitic rocks further west and south. A creek in Portion 309, Parish Congo, exposes the junction with underlying granite.

No fossils have yet been found in these beds. A small amount of gold may be washed from the conglomerate bands, and no doubt has its origin in the gold-bearing quartz-veins through the slate and quartzites of the Mogo and Mt. Dromedary Goldfields.

In certain localities, for example in Portions 960, 232, 159, 1, 2, Parish Congo, the sandstone or conglomerate has been converted into hard flinty quartzite, and in one locality (Portion 309) a certain amount of common opal has been developed. It is not known whether this

apparently high-grade quartzite or "silica" is present in commercial quantities, but the present indications are not very promising, as the silicification appears to have been very local. The unsilicified conglomerate is used locally as road-metal. The formation of this quartzite has been caused by flows of basalt, which have covered parts of the sedimentary formation.

Columnar basalt outcrops along the coast at Congo Point, and at each of the headlands south as far as Meringo Point, and occurs in irregular patches through the bushland towards Coila, capping the hills round the western end of Lake Coila.

In Portion 960, Parish Congo, this basalt is being denuded, and the underlying silicified sandstones and conglomerates are being exposed. The basalt appears to have flowed along channels, denuded out of the old sandstone surface.

Lithologically, the basalt is sometimes compact, but is often vesicular, when the vesicles may be lined with chlorite or zeolites. The grainsize varies from fine to medium, and the texture is pilotaxitic or quite often ophitic. It consists of olivine, plagioclase (labradorite), augite, and iron ore, with a certain amount of secondary material.

Tertiary Rocks near Milton.

In the Milton District there are similar occurrences of Tertiary sediments and associated basalt flows.

The silicified portions of the Tertiary sediments are quarried for use in the manufacture of high grade "silica-brick" for use in steel-furnace work, and the occurrence has been the subject of various reports in publications of the Department of Mines, New South Wales [8, 9, 10]. It is considered there, that the origin of the so-called "silica"

rock is "the intrusion of volcanic dykes into beds of Upper Marine age."

The present writer is unable to agree with this diagnosis of the origin, for reasons which will now be discussed.

The hard, flinty quartzite, locally known as "silica," is the rock most resistant to erosion of all the Tertiary beds in the district. Associated with it are clays and loosely-compacted sandstones, which rapidly disintegrate as a result of weathering, producing a soil apparently not unlike that resulting from the Upper Marine sandstones, although it is believed to support a different flora.

The quartzite has been found in patches over quite a wide area. Small patches near the township of Ulladulla are now worked out, as well as the rolled boulders which were first located at Flint Point. At present it is quarried at Bannister Head, and in the bushlands a mile or so to the west, where the Newbold Silica Brick Company and the Ulladulla Silica Brick Company have a number of mining leases. These companies have also leases south and west of Pattimore's Lagoon, about four miles north of Bannister, where there is an extensive deposit of quartzite, which has been proved, by means of a number of trenches and open cuts, to extend over an area of about 150 acres, as a horizontal bed with an average thickness of about six feet. Other deposits are worked at Red Head, still further north, and in patches along the ridge to the west for a distance of over a mile from the coast.

The physiography of the coastal area between Bannister Head and Red Head is rather interesting. The eastern portion of Bannister Head, the headland at the southern entrance to Narrawallee Creek, and the main portion of Red Head, are residuals of Upper Marine Sandstone, which rise to about 60 feet above sea level. The areas between

these headlands consist chiefly of recent deposits of sandy material, only a few feet above sea-level, extending from behind the sand-dunes bordering the beaches, for a distance of about a mile inland; the deposits are covered by scrub typical of such areas. At intervals there are hills rising about 80 feet above sea-level, and it is on the tops of these elevations that the quartzite beds occur *in situ.*

At Bannister Head there is an overlap of the quartzite on the underlying Permo-Carboniferous beds, with a slight angular unconformity.

Each of the quartzite beds examined occurs at a height of 75 feet above sea level. The beds vary from two to nearly fifteen feet in thickness, and are only limited in lateral extent by the natural fall of the land.

Underlying the quartzite in one of the quarries at Bannister, is a soft clay. In most areas the top of the quartzite bed is exposed at the surface of the ground, but isolated boulders of basalt are scattered over the surface in a number of places, and a definite flow of columnar basalt occurs *in situ* immediately on top of the quartzite, at the eastern portion of the deposit at Pattimore's.

Lithologically, the Tertiary beds are quite unlike the neighbouring Upper Marine beds. Analyses of the quartzite made by the Department of Mines, show the presence of over 98 per cent. of silica [10]. In the hand specimen, the quartzite is usually a dense, flinty rock, like "grey-billy" [5]. Under the microscope, it is seen to consist of irregular grains of quartz, cemented by cryptocrystalline, siliceous material.

Large blocks of the quartzite, which have been formed as a result of jointing, frequently contain in the centre crumbly white sandstone or even loose sand. An analysis of some of this sandstone showed 97.30 per cent. of silica.

These beds are lithologically similar to beds of proved
Tertiary age in other parts of the State, such as those of
the New England District [5].

Pieces of "charcoal" and silicified fragments of plant
stems and roots are abundant in the quartzite in two of the
quarries, which have been worked up to the present. These
occur about a mile west of Bannister. No definite fossils
have yet been found elsewhere, but there are likely
indications in portions of the Pattimore's deposit.

A well preserved specimen of wood from the quartzite
has been examined microscopically by Mr. C. Barnard,
B.Sc., who identified it as portion of the stem of a
dicotyledonous angiosperm, fixing the horizon possibly as
old as Lower Cretaceous, but most probably Tertiary. Mr.
Barnard's description of this fossil wood is appended. The
nature and mode of occurrence of these Tertiary beds
suggest that they have been deposited under fairly still-
water conditions, in erosion hollows in the Upper Marine
Beds.

The Origin of the Quartzites.

The theory that the silification of the sandstones is due
to the influence of dykes is rejected for several reasons.
The writer has nowhere found any evidence of dykes in
association with the quartzite. The structure indicated on
the map in the Reports [10] previously mentioned as a dyke
on the northern side of Bannister Head, proves to be a sill
or interbedded flow of columnar basalt, varying in thickness
from about 8 to 25 feet, well exposed by the cliff section.
It overlies sandstones and carbonaceous clays, and is again
exposed in the cliff section on the south-western side of
Bannister Head. The photograph (reproduced in Bull. No.
10 facing p. 13), which was taken from the top of Bannister
Head, clearly shows the base of this basalt.

(1) Mitchell's Quarry, near Bannister, from which fossil angiosperms were obtained, showing the exposed upper surfaces of the horizontal bed of quartzite, which has an average thickness of about six feet.
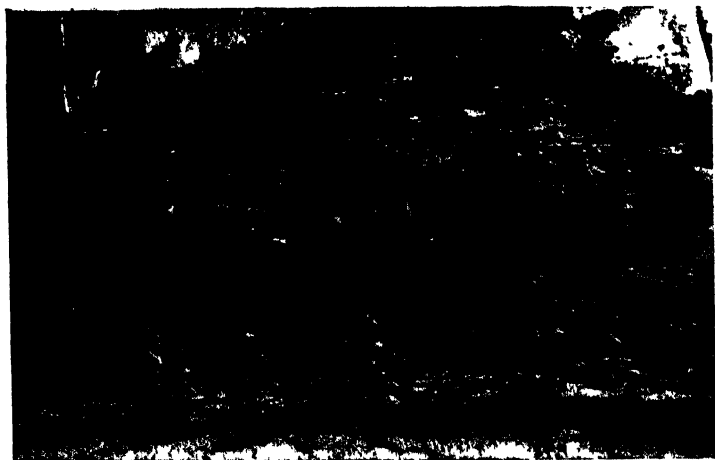
(2) Columnar basalt exposed in the cliff section on the north-west of Bannister Head. It takes the form of a sill in the Tertiary sediments.

It is considered that the conversion of the sandstones into hard, flinty quartzite is a contact metamorphic effect of flows of Tertiary basalt. Remnants of these flows still remain over the quartzite at Pattimore's Lagoon deposit, and odd boulders of basalt occur over the quartzite in the Bannister area. As a rule, however, the basalt has been denuded and the underlying resistant quartzite is exposed. Outcrops of similar basalt, not associated with quartzite, occur as flows near the main road a mile north of Ulladulla, and also on a hill at the south-western end of Lake Conjola.
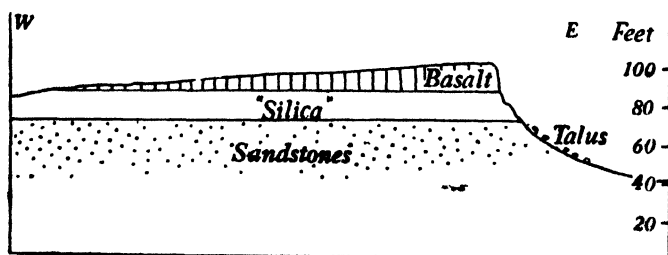
Diagrammatic Section through the eastern portion of the deposit south of Pattimore's Lagoon, showing the relation of the quartzite ("silica") to the overlying columnar basalt.

Lithologically the rock is generally a pilotaxitic, olivine basalt. It is sometimes compact, but is usually amygdaloidal, the amygdules consisting of radiating zeolite, chlorite or calcite. The basalt outcropping near Lake Conjola, which looks remarkably fresh in the hand-specimen, contains a large amount of interstitial calcite, which is undoubtedly primary.

The newer basalts of this district may be compared directly with Tertiary basalts occurring elsewhere in this State, such as at Robertson, Wingello, etc. A petrographic description and a chemical analysis of the Robertson basalt is published in Memoir No. 10 of the Geological Survey of

New South Wales, 1915, p. 288, and other analyses are quoted by C. A. Sussmilch [14]. The exact age of these basalts is still a subject of controversy, but in his Presidential Address to the Royal Society of New South Wales [14], Sussmilch classified them as the Plateau Basalts and assigned to them an Upper Miocene or Pliocene age.

Although it is generally accepted that hydro-thermal solutions carrying silica may accompany outpourings of basic, volcanic rocks, it is difficult to conceive of this association of olivine basalt and siliceous solutions. It is considered that the high percentage of silica (97.3) present in the analysis of friable sandstone, from the central portion of a mass of quartzite from Pattimore's deposit, is an indication that the original material, from which the quartzite was derived, was a comparatively pure sand or sandstone, and that no additional silica was derived from the hydrothermal solutions, which may have accompanied the basalt.

L. F. Harper [10] (1924, p. 12), is also of the opinion that the quartzite has been derived from "a bed of comparatively pure sandstone or grit," which was horizontally bedded, although he states that "The intrusion of volcanic dykes appears to have been accompanied by hydrothermal solutions heavily charged with silica, which, under favourable conditions, permeated the beds adjacent to the intrusions, and converted them into quartzites."

A comparison of the analyses of the Ulladulla quartzites and loose unconsolidated sands from dunes and beaches of the Sydney district, is of interest in this connection. These analyses are published in Bulletins Nos. 10 and 15 of the Department of Mines, New South Wales [10, 13] and typical examples are quoted below.

I.—Quartzite, Por. 2, Parish of Ulladulla.

II.—Sandstone from centre of quartzite boulder, Pattimore's Lagoon. (Analyst: I. A. Brown.)

III.—Dune Sand, Bondi.

IV.—Sand, La Perouse.

	I. No. 2764.	II.	III.	IV.
SiO_2	98.56	97.30	98.87	98.00
Al_2O_3	0.85	—	} 0.25	1.26
Fe_2O_4	0.15	—		—
CaO	—	—	—	0.14
$CaCO_3$	—	—	0.99	—
MgO	—	—	—	0.05
H_2O	0.32	—	—	0.44
	99.88	—	100.11	99.89

It will be seen that the consolidation and cementation of these recent sands might result in the formation of rock similar to the Ulladulla quartzite, without the introduction of additional silica. This could be brought about by the circulation of waters, which might be either of magmatic origin, or waters originally contained in the sands and heated by flows of basalt. The porous nature of the sands would no doubt facilitate the circulation of the waters. In this connection it may be noted that in general, the metamorphic effect of Tertiary basalt on sandstones in this State, has been to produce columnar structure, with a certain amount of hardening, in Mesozoic and older sandstones, whilst the newer Tertiary beds have been converted into dense, flinty quartzites, like "grey-billy."

Summarising, the writer now assigns a Tertiary age to the Ulladulla quartzites and associated beds for the following reasons:—

(1) They are unconformable with the Upper Marine Beds.

(ii) They are lithologically unlike the Upper Marine Beds.

(iii) They are lithologically similar to beds of proved Tertiary age in other parts of the State.

(iv) They contain silicified and well-preserved fragments of the stems and roots of a dicotyledonous angiosperm, most probably of Tertiary age.

The theory that the quartzites are due to the influence of dykes is rejected for the following reasons:—

(i) The writer has found no evidence of any dykes in association with the quartzites.

(ii) The quartzite has its greatest extent horizontally, occurring as horizontal beds, which have an average thickness of about six feet.

(iii) There are, in the district, remains of Tertiary lava flows, which at least in one locality directly overlie the quartzite.

In conclusion, the writer wishes to thank residents for their kindness during field investigations. Special thanks are due to Mr. Ilslow, of Milton, for providing information concerning, and facilities for examining the quarries under his control.

NOTE ON FOSSIL WOOD.

By C. BARNARD, B.Sc.,

Demonstrator in Botany, Sydney University.

In one piece of silicified wood from Bannister. near Ulladulla, the structure has been sufficiently well preserved to be distinguished as that of a dicotyledonous angiosperm.

The specimen consists of a piece of the secondary xylem of a stem.

In transverse section annual rings are well defined. The vessels are numerous, of medium size (0.075 mm. average), and are evenly distributed throughout the wood. Wood fibres with thick walls, interspersed with parenchyma cells, compose the matrix. The medullary rays are numerous, and generally two cells in width and 12-15 cells high.

In longitudinal section two kinds of pitting are apparent on the walls of the vessels. In some cases it is of a rather narrow scalariform type, while in others this is replaced by series of regularly arranged simple, round, or slightly oval-shaped pits. The ring-porous type of perforation is found on the majority. In some cases, however, there is a very oblique end wall upon which numerous bordered pits and one or two large perforations are situated.

The wood fibres present no features of interest.

The parenchyma cells occur in definite vertical rows in longitudinal section. The cells are short, and oval to rectangular in shape.

The walls of the medullary ray cells are fairly thick. Small round to oval pits can be distinguished on their walls, both in surface view and in section.

In all respects this stem presents no unusual features. It has the structure of a typical woody dicotyledon. The comparative anatomy of the angiosperms is not sufficiently understood at present to establish the genetic relationships or affinities of a stem without a great deal of laborious research. As the piece of wood described presents no outstanding features or peculiarities by which it may be distinguished, it does not seem necessary for present purposes to attempt to assign it to any particular Family.

The earliest authentic record of angiosperm remains is that of Thomas (1921), who has described fruits from the Middle Jurassic, England. From the Upper Cretaceous

to Tertiary times remains are abundant. In the Lower Cretaceous only 5 fossil stems have been described (Stopes 1912), and from the Upper Cretaceous 5 from Japan (Stopes and Fujii, 1909), and several others by different authors. Though there are few records of descriptions, fossil wood is known to be fairly abundant in the Tertiary.

It thus seems that though this specimen might indicate any horizon above the Lower Cretaceous, it is most likely that we are here dealing with a Tertiary fossil.

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ABSTRACT OF PROCEEDINGS

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Royal Society of New South Wales.

MAY 6TH, 1925.

The Annual Meeting, being the four hundred and fifty-second General Monthly Meeting of the Society, was held at the Society's House. 5 Elizabeth Street, Sydney, at 8 p.m.

Dr. C. Anderson, President, in the Chair.

Forty-six members were present.

The Minutes of the General Monthly Meeting of the 3rd December, 1924, were read and confirmed.

The certificates of two candidates for admission as ordinary members were read: one for the second, and one for the first time.

The following gentleman was duly elected an ordinary member of the Society:—Claude Henry Ollé.

It was announced that the following members had died during the recess:—Mr. H. E. Barff, Mr. W. H. Baxter, Professors W. A. Haswell and J. I. Hunter, and Dr. W. Botting Hemsley an Honorary member.

Letters were read from Mrs. W. H. Baxter, Mrs. W. A. Haswell and Mrs. J. I. Hunter ·expressing thanks for the Society's sympathy in their recent bereavements.

The Annual Financial Statement for the year ended 31st March, 1925, was submitted to members and on the motion of Professor Chapman was adopted —

GENERAL ACCOUNT.
RECEIPTS.

	£ s. d.	£ s. d.	£ s. d.
To Revenue—			
Subscriptions		729 15 0	
„ Rents—			
Offices	679 16 0		
Hall and Library..	299 9 5		
		979 5 5	
„ Sundry Receipts		28 2 10	
„ Government Subsidy for 1924		400 0 0	
			2137 3 3
„ Clarke Memorial Fund—			
Loan to General Fund			
(interest)			59 16 5
„ Building Loan Fund			1150 0 0
„ Building Investment Fund—			
Loan to General Fund..			400 0 0
„ Balance—Union Bank of			
Australia Ltd.—			
Overdrawn Account,			
Head Office		2008 2 7	
Less Petty Cash on			
Hand		5 0 3	
			2003 2 4
			£5750 2 0

PAYMENTS.

	£ s. d.	£ s. d.	£ s. d.
By Balance—31st March, 1924			3463 19 0
„ Administrative Expenditure—			
„ Salaries and Wages—			
Office Salary and Accountancy Fees	259 15 0		
Assistant Librarian ..	48 0 0		
Caretaker	241 5 9		
		549 0 9	
„ Printing, Stationery, Advertising and Stamps—			
Stamps and Telegrams	45 15 6		
Office Sundries, Stationery, &c.	10 15 5		
Advertising	11 7 0		
Printing	60 16 0		
		128 13 11	

„ Rates, Taxes and Services—
    Electric Light 74 1 11
    Gas 11 9 4
    Insurance 32 15 6
    Rates 198 11 7
    Telephone 12 1 3
                        —————— 328 19 7
„ Printing   and   Publishing
    Society's Volume—
    Printing, etc. 358 13 2
    Bookbinding 41 10 0
                        —————— 400 3 2
„ Library—
    Books and Periodicals.. 68 12 2
    Bookbinding 98 9 0
                        —————— 167 1 2
„ Sundry Expenses—
    Repairs 28 6 6
    Lantern Operator 17 17 0
    Bank Charges 0 4 7
    Sundries 32 16 10
                        —————— 79 4 11
                              ————————1653 3 6
„ Interest—
    Union Bank of Australia
      Ltd. 133 3 9
    Clarke Memorial Fund   59 16 5
    Building Loan Fund ..   39 18 6
                        —————— 232 18 8
„ Building   and   Investment
    Fund 400 0 0

                                  £5750 2 0

CLARKE MEMORIAL FUND.

BALANCE SHEET AS AT 31st MARCH, 1925.

LIABILITIES.

                     £ s. d. £ s. d.
Accumulation Fund—
  Balance as at 31st March, 1924 .. 905 11 10
  Additions during the year—
  Interest and General Fund 59 16 5
                       —————— 965 8 3

                               £965 8 3

ASSETS.

	£	s.	d.
Loan to General Fund	965	8	3
	8	3	

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31st MARCH, 1925.

RECEIPTS.

	£	s.	d.
To Interest—Loan to General Fund	59	16	5
	£59	16	5

PAYMENTS.

	£	s.	d.
By Loan to General Fund	59	16	5
	£59	16	5

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D.,
Honorary Treasurer.
(Sgd.) W. PERCIVAL MINELL, F.C.P.A.,
Auditor.

Sydney, 18th April, 1925.

On the motion of Professor Chapman, seconded by Dr. Greig-Smith, Mr. W. P. Minell was duly elected Auditor for the current year.

It was announced that the Council had awarded the Clarke Memorial Medal to Mr. Charles Hedley, F.L.S., and the President then made the presentation. Mr. Hedley expressed his appreciation of the Council's action in making the award.

The President announced that Popular Science Lectures for the Session were being arranged.

The Annual Report of the Council was read, and on the motion of Professor Vonwiller, seconded by Mr. R. H. Cambage, was adopted:—

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1924-1925.

(1st May to 29th April).

The Council regrets to report the loss by death of ten ordinary members and one honorary member. Eight members have resigned. On the other hand, twenty-three ordinary members have been elected during the year. To-day (29th April, 1925) the roll of members stands at 379.

During the Society's year there have been eight general monthly meetings and ten Council meetings.

Four Popular Science Lectures were given, namely:—

June 19—"Conditions of Life and Travel in the Interior of Australia," by W. G. Woolnough, D.Sc., F.G.S.

July 17—"Experimental Observations on the Organisation of the Human Nervous System," by Prof. J. I. Hunter, Ch.M., D.Sc.

August 21—"Solar Radiation," by J. J. Richardson, A.M.I.E.E.

September 18—"Science and the Land Industries," by Prof. R. D. Watt, M.A., B.Sc.

Meetings were held throughout the Session by the Sections of Geology, Agriculture and Industry.

The inaugural meeting of the Section of Physical Science was held on Thursday, 16th October, 1924, the following officers being elected:—

Chairman—Professor O. U. Vonwiller.

Hon. Secretaries—Professor V. A. Bailey, Mr. J. J. Richardson.

Committee—Rev. E. F. Pigot, Prof. J. P. V. Madsen, Mr. A. B. B. Ranclaud, Mr. E. M. Wellish.

Twenty-two papers were read at the Monthly Meetings and covered a wide range of subjects. In most cases they were illustrated by exhibits of interest.

The Council has awarded the Clarke Memorial Medal to Mr. Charles Hedley, F.L.S.

The following members have been honoured during the year:—J. J. C. Bradfield, D.Sc., Engineering and University Medal; Dr. L. A. Cotton, to the Chair of Geology in the University of Sydney; Sir Edgeworth David, Honorary Degree of Correspondent to the Geological Society of America; Prof. J. I. Hunter, M.D., and University Medal; Prof. J. Kenner, F.R.S.; John Sulman, Knight Bachelor; Dr. R. J. Tillyard, F.R.S.; G. A. Waterhouse, D.Sc. and University Medal.

At the meeting held on 27th May, 1924, the Society had the pleasure of the presence of Dr. V. Stefansson, the Arctic Explorer, and of Mr. David Unaipon, a descendant of the Aboriginals, on the 3rd December.

The Annual Dinner took place at "The Marlborough", 92 King Street, Sydney, on Tuesday, 28th April, 1925, when we were honoured by His Excellency Sir Dudley Rawson Stratford de Chair, K.C.B., M.V.O., Governor of New South Wales and by the Presidents of several societies.

Owing to the expansion of the Institution of Engineers, Australia, that body found it necessary to secure more commodious premises and vacated the rooms which had been occupied in this Society's House.

As new tenants the Society now has the Australian Association for the Advancement of Science, Wireless Institute of Australia, N.S. Wales Chamber of Agriculture and the Institute of Optometrists of N.S. Wales.

The donations to the Library have been as follows:— 34 volumes, 779 parts, 10 reports, 3 maps and 1 calendar.

The following ·donations were laid upon the table:—
373 parts, 9 volumes, 2 maps, 1 report and 1 calendar.

The President, Dr. C. Anderson, then delivered his address.

There being no other nominations, the President declared the following gentlemen to be officers and council for the coming year:—

President:
Professor R. D. WATT, M.A., B.Sc.

Vice-Presidents:

J. NANGLE, O.B.E., F.R.A.S.	C. A. SUSSMILCH, F.G.S.
E. C. ANDREWS, B.A., F.G.S.	C. ANDERSON, M.A., D.Sc.

Hon. Treasurer
Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries:

R. H. CAMBAGE, F.L.S.	R. GREIG-SMITH, D.Sc., M Sc

Members of Council:

R. W. CHALLINOR, F.I C., F.C.S.	G. HARKER, D S.
E. CHEEL.	Rev. E. F. PIGOT, S J., B.A., M.B.
Prof. L. A. COTTON, M.A. D.Sc	W. POOLE, M E., M Inst. C.E., M I.M M., M.I.E. Aust., M A.m I.M E
Prof. Sir EDGEWORTH DAVID, K.B.E., C.M.G., D.S.O, F.R S., D Sc	Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.
W. S. DUN.	W G. WOOLNOUGH, D Sc., F.G.S.

The out-going President then installed Professor R. D. Watt as President for the ensuing year, and the latter briefly returned thanks.

On the motion of Dr. Woolnough a hearty vote of thanks was accorded to the retiring President for his valuable address.

Dr. C. Anderson briefly acknowledged the compliment.

JUNE 3RD, 1925.

The four hundred and fifty-third General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Twenty-four members were present.

The Minutes of the preceding meeting were read and confirmed.

The President announced that Mr. R. H. Cambage had received the honour of Commander of the Order of the British Empire, and suggested that a telegram be sent conveying the congratulations of the members upon his having received the well-deserved honour.

The certificates of six candidates for admission as ordinary members were read: one for the second and five for the first time.

The following gentleman was duly elected an ordinary member of the Society :—Ernest John Bryce.

It was announced that since our last meeting Dr. Eric Sinclair had died. He had been a member for forty-three years.

A letter was read from Mrs. H. E. Barff expressing thanks for the Society's sympathy in her recent bereavement.

The following donations were laid upon the table:— 6 volumes and 76 parts.

The President called the attention of members to the Donovan Lecture to be delivered on June 18th, by Professor O. U. Vonwiller at the University of Sydney.

The President announced that Sir Joseph Carruthers, K.C.M.G., etc., would deliver a Popular Science Lecture upon "The Hawaiian Islands", in the Society's Hall on June 25th, 1925.

THE FOLLOWING PAPER WAS READ:

"The Essential Oil of *Boronia citriodora* and the Occurrence of Citronellol," by A. R. Penfold, F.A.C.I., F.C.S.

Remarks were made by Professor J. Kenner, Messrs. R. W. Challinor and E. Cheel.

EXHIBITS:

1. Mr. G. Hooper exhibited specimens of the timber of *Pinus radiata,* popularly known as *P. insignis,* which were remarkably free from knots.

Mr. M. B. Welch described the specimens and remarked upon the suitability of the soft timbers for general building purposes.

Remarks were made by Professor Douglas Stewart, Messrs. R. T. Dalrymple-Hay, W. Freeman, J. Farrell, E. Cheel and the President.

2. Dr. G. Harker exhibited specimens of celanese or artificial silk and discussed the manufacture of artificial silk generally and the dyeing of the manufactured material.

Remarks were made by Professor Douglas Stewart and Mr. E. G. Bishop.

JULY 1ST, 1925.

The four hundred and fifty-fourth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Twenty-eight members were present.

The minutes of the preceding meeting were read and confirmed.

The President referred to the honour of C.B.E., recently conferred upon Mr. R. H. Cambage and conveyed to him personally the congratulations of the members. Mr. Cambage thanked the President and members.

The certificates of five candidates for admission as ordinary members were read for the second time.

The following gentlemen were duly elected ordinary members of the Society:—Norman Bartlett Friend, John Smith Purdy, Theodore Cleveland Roughley, Cyrus Willmott Oberon Tye and Lucien Barker-Woden.

A letter was read from the relatives of Dr. Eric Sinclair expressing thanks for the Society's sympathy in their recent bereavement.

The following donations were laid upon the table:— 396 parts, 6 volumes and 19 reports.

THE FOLLOWING PAPERS WERE READ:

1. "A third contribution on the Homologies of the Parasphenoid Ectopterygoid and Pterygoid Bones and of the Metapterygoid," by H. L. Kesteven, D.Sc., M.D.

2. "The Parabasal Canal and Nerve Foramina and Canals in the Bird Skull," by H. L. Kesteven, D.Sc., M.D.

In the absence of the author, these two papers were briefly described by Dr. C. Anderson.

3. "Note on the Identity of Uncineol with Eudesmol," by A. R. Penfold, F.A.C.I.

Remarks were made by Dr. G. Harker.

4. "Multiple Births, their Characteristics and Laws mathematically considered," by Sir George Knibbs, C.M.G., F.S.S., F.R.A.S.

In the absence of the author, the paper was described by Professor H. G. Chapman.

Remarks were made by Professor Douglas Stewart, Dr. G. Harker, Messrs. W. Freeman, A. A. Hamilton and Professor Chapman.

AUGUST 5TH, 1925.

The four hundred and fifty-fifth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Twenty-nine members were present.

The minutes of the preceding meeting were read and confirmed.

The certificate of one candidate for admission as an ordinary member was read for the first time.

The President announced that Associate-Professor H. Priestley, M.D., Ch.M., would deliver a Popular Science Lecture on "Vitamines" on Thursday, 20th August, 1925.

The President announced that the good wishes of the Society would be tendered to Sir Edgeworth David by members prior to his leaving for England, and that the function would probably take place on Friday, 14th instant, at 4 p.m.

The following donations were laid upon the table:— 63 parts, 4 volumes and 3 reports.

THE FOLLOWING PAPERS WERE READ:

1. "The Essential Oils from the Leaves of *Murraya koenigii* (Spreng), *Murraya exotica* (Linn.) and *Murraya exotica* var. *ovatifoliolata* (Engler)," by A. R. Penfold, F A C.I., and Professor J. L. Simonsen, D.Sc., F.I.C., F.A.S.B.

Remarks were made by Mr. Cheel.

2. "Description of sixteen New Species of Eucalyptus," by J. H. Maiden, I.S.O., F.R.S., and W. F. Blakely.

Remarks were made by Mr. R. H. Cambage and Dr. G. Harker.

A paper on "The Kosciusko Plateau," a Topographic Reconnaissance, by Associate-Professor Griffith Taylor, D.Sc., B.E., B.A., Assistant-Professor W. R. Browne, D.Sc., and F. Jardine, B.Sc., was postponed until next meeting owing to the absence of the authors.

SEPTEMBER 2ND, 1925.

The four hundred and fifty-sixth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Twenty-seven members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificate of one candidate for admission as an ordinary member was read for the second time.

The following gentleman was duly elected an ordinary member of the Society:—William E. Clark.

The President offered the greetings of the Society to Mr. A. D. Ollé on his return after a trip abroad. Mr. Ollé replied describing his travels and mentioning the scientific men he had met, many of whom had, through him, sent their greetings to the Society.

The President announced that an informal meeting of members would take place on Monday, September 14th, at 4 p.m., to welcome Sir Ernest Rutherford, who had just arrived at Adelaide from England.

The President announced that Professor J. Kenner would deliver a Popular Science Lecture on "The Influence of Organic Chemistry on Economic Conditions", on Thursday, September 17th, 1925.

The following donations were laid upon the table:— 295 parts, 2 volumes, 3 reports and 1 map.

THE FOLLOWING PAPERS WERE READ:

1. "The Kosciusko Plateau," a Topographic Reconnaissance, by Associate-Professor Griffith Taylor, D.Sc., B.E., B.A., Assistant-Professor W. R. Browne, D.Sc., and F. Jardine, B.Sc.

In the absence of the authors the paper was read by Mr. R. H. Cambage.

2. "The Essential Oil of *Eriostemon myoporoides* (De Candolle)," by A. R. Penfold, F.A.C.I., F.C.S.

In the absence of the author the paper was read by Mr. F. R. Morrison.

Remarks were made by Messrs. R. H. Cambage, E. Cheel and R. W. Challinor.

3. "The Human Sex-Ratio and the Reduction of Masculinity through Large Families," by Sir George Knibbs, C.M.G., Hon. F.S.S.

In the absence of the author the paper was read by Professor H. G. Chapman.

4. "Molecular Solution Volumes and Association," by G. J. Burrows, B.Sc, and A. E. James, B.Sc.

EXHIBIT:

Professor H. G. Chapman on behalf of Dr. J. M. Petrie exhibited specimens of mesentery stained to show the presence of potassium in the intercellular cement between the endothelial pavement cells.

OCTOBER 7TH, 1925.

The four hundred and fifty-seventh General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Twenty-seven members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two candidates for admission as ordinary members were read for the first time.

The President announced that the Hon. Sir Joseph Carruthers, K.C.M.G., etc., would deliver a Popular Science Lecture on "The Hawaiian Islands", on Thursday, 22nd October, 1925.

The following donations were laid upon the table:— 136 parts, 2 volumes and 5 reports.

THE FOLLOWING PAPERS WERE READ:

1. "Acacia Seedlings," Part XI., by R. H. Cambage, C.B.E., F.L.S.

2. "Further Observations on *Stachys arvensis*," Stagger Weed as a Cause of Staggers or Shivers in Sheep, by H. R. Seddon, D.V.Sc., W. L. Hindmarsh, B.V.Sc., M.R.C.V.S., and H. R. Carne, B.V.Sc.

In the absence of Dr. Seddon, the paper was read by Mr. Max Henry and Mr. Carne.

Remarks were made by Messrs. A. D. Ollé, A. R. Penfold and Dr. S. Dodd.

3. "The Fixed Oil of the Seeds of the Kurrajong," by F. R. Morrison, A.S.T.C.

Remarks were made by Messrs. W. M. Doherty, A. R. Penfold and S. Birrell.

4. "Notes on the Principal Indigenous Timbers of the Natural Order Saxifrageae," by M. B. Welch, B.Sc., A.I.C.

5. "The use of Phosphorus Pentachloride in the preparation of Glycerides," by R. K. Newman, V. M. Trikojus, B.Sc. and G. Harker, D.Sc.,

The paper was read by Dr. Harker and remarks were made by Mr. R. W. Challinor.

EXHIBIT:

Mr. R. Grant exhibited a water sampler, an apparatus for taking samples of water at various depths for bacteriological examination.

NOVEMBER 4TH, 1925.

The four hundred and fifty-eighth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Twenty-six members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three candidates for admission as ordinary members were read : two for the second and one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—Harris Eric Marshall Curry and Charles Adrian Jenkins.

The following donations were laid upon the table:— 72 parts, 4 volumes, 6 reports, 1 map and 2 calendars.

THE FOLLOWING PAPERS WERE READ :

1. "The Constitution of Australol," by J. C. Earl, B.Sc., Ph.D., and V. M. Trikojus, B.Sc.

The paper was read by Dr. Earl and remarks were made by Messrs. R. W. Challinor, A. R. Penfold and Prof. J. Kenner.

2. "The Essential Oils of *Melaleuca linariifolia* (Smith) and *Melaleuca alternifolia* (Cheel)," by A. R. Penfold, F.A.C.I., F.C.S.

Remarks were made by Prof. J. Kenner.

3. "Note on the Earthquakes at Murrumbateman during March and April, 1924, and January to April, 1925," by Prof. L. A. Cotton, M.A., D.Sc.

Remarks were made by Dr. W. G. Woolnough and Assistant-Professor W. R. Browne.

4. "The Identification of the Principal Ironbarks and Allied Woods," by M. B. Welch, B.Sc.

DECEMBER 2ND, 1925.

The four hundred and fifty-ninth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Twenty-nine members were present.

The minutes of the preceding meeting were read and confirmed.

The President announced the death of the Queen Mother, Queen Alexandra, and stated that the Council had passed a resolution of sympathy with the Royal family.

The President announced the death of Mr. J. H. Maiden, who had been a member of this Society for forty-two years, twenty-nine years a member of the Council, of which period he was two years President and twenty-two years Honorary Secretary.

The President also announced that the following resolution had been passed by the Council:—

"That the members of the Council of the Royal Society of New South Wales desire to record in the minutes their great sorrow at the death of their most highly esteemed and beloved colleague, Joseph Henry Maiden, and to express their great appreciation of his unselfish and valuable assistance given to this Society for so many years, of his monumental work in the field of Australian botany, and also of his eminent service in the advancement of science throughout the Commonwealth."

This resolution was endorsed by members, all standing.

The certificate of one candidate for admission as an *ordinary member was read for the second time.*

The following gentleman was duly elected an ordinary member of the Society:—George Augustine Taylor.

The following donations were laid upon the table:—8 volumes, 175 parts, 3 reports and 2 calendars.

THE FOLLOWING PAPERS WERE READ:

1. "The Germicidal Values of some Australian Essential Oils and their pure constituents, together with those for some Essential Oils," Part iii., by A. R. Penfold, F.A.C.I., F.C.S. and R. Grant, F.C.S.

Remarks were made by Messrs. R. W. Challinor and W. M. Doherty.

2. "The Essential Oil of *Baeckea Gunniana*, var. *latifolia* (F.v.M.)," by A. R. Penfold, F.A.C.I., F.C.S.,

Remarks were made by Dr. G. Harker.

3. "The Tannins of the Black Cypress Pine ('*Callitris calcarata* R. Br.), and their Distribution in the Bark," by F. A. Coombs, A.A.C.I., W. McGlynn, and M. B. Welch, B.Sc.

Remarks were made by Mr. A. R. Penfold and the President.

4. "On the Occurrence of water-worn Pebbles of Coal in the Upper Coal Measures at Red Head, N.S.W.," by C. A. Sussmilch, F.G.S.

Remarks were made by Mr. G. D. Osborne and Assist.-Professor W. R. Browne.

5. "Some Tertiary Formations on the South Coast of N.S. Wales," with special reference to the Age and Origin of the so-called "Silica" Rocks, by Miss Ida A. Brown, B.Sc. (communicated by Professor L. A. Cotton, D.Sc.).

Remarks were made by Assist.-Professor W. R. Browne, Mr. R. H. Cambage and Dr. G. Harker.

GEOLOGICAL SECTION.

GEOLOGICAL SECTION.

—◆—

Annual Meeting, May 15, 1925.

Professor Sir Edgeworth David in the Chair.

Eleven members and four visitors were present.

Professor Sir Edgeworth David was re-elected Chairman for the year. Mr. E. C. Andrews was elected Chairman on the departure of Professor Sir Edgeworth David for England, and Mr. T. Hodge Smith, Honorary Secretary.

Mr. Chester Washburn delivered a lecturette, illustrated by lantern slides, on "A New Conception of Geological Faults". The lecturer stated that faults are caused by compression and not by tension. The compression forces on rocks gradually become greater until the elastic limit of the rock is reached, when faulting takes place with a sudden sharp movement. In the case of a normal fault the hanging wall side does not subside but the footwall side is pushed up. Furthermore, the fault plane is a curved surface, concave to the footwall side. Applying this principle to Rift-valleys the fault planes on either side of the Valley are the result of different periods of faulting, and thus it is possible to find a hoist underground vertically below what is a trough on the surface.

Messrs. E. C. Andrews and C. A. Süssmilch, Professor L. A. Cotton and the Chairman discussed the views put forward by Mr. Washburn.

June 19, 1925.

Professor Sir Edgeworth David in the Chair.

Fourteen members were present.

EXHIBITS:

1. By Rev. R. T. Wade—Stalactites of carbonate of lime taken from a cave at National Park, New South Wales. The cave occurs in sandstone and the supply of lime is derived from solutions reaching the cave through joint planes and cracks in the sandstone. It was decided to approach the Trustees of the National Park seeking adequate protection for such interesting caves.

2. By Prof. L. A. Cotton—An insect's wing (fossil) from Belmont, New South Wales.

3. By Mr. G. D. Osborne and Dr. A. B. Walkom—A zygopterid stem (*Clepsydropsis australis*). The material was obtained in a coarse conglomerate of Kuttung age, probably at least 2000 feet above the base of the Kuttung Series.

4. By Assistant-Professor W. R. Browne—A specimen of the Cambewarra Trachyte, unusually amygdaloidal, giving the rock an appearance of conglomerate.

5. By Mr. G. W. Card, from the Mining and Geological Museum—(a) Cambrian Trilobites from China. (b) Sandstone "Balls" from the Broken Hill Proprietary Silica Quarry, Wondabyne, Hawkesbury River, New South Wales.

Mr. C. A. Sussmilch delivered a lecturette on the physiography of the Hunter River Valley, illustrated by maps and sections. The lecturer stated that the region is primarily a tectonic feature much modified by subsequent denudation. During the uplift which produced the main tableland of New South Wales, this region lagged behind, being uplifted only from 1200-1500 feet, whereas the block

to the north (New England) was uplifted 3000-5000 feet, and that to the south (The Blue Mountains) about 3000 feet. Great fault scarps in part mark the junction between the lower and higher blocks. The western part of the Hunter River tableland (Merriwa Tableland) was shown to extend across the Main Divide in a westerly direction without any break, and to be continuous with the Mudgee-Coolah Tableland. The Hunter River Tableland is in itself not a simple block but varies in altitude and is in places warped and faulted. The uplift which produced the tableland was intermittent, there being well-marked erosion levels at 400 feet and 125 feet above the present base level.

Remarks were made by Professor Griffiths Taylor. Assistant-Professor W. R. Browne, Messrs. G. D. Osborne and M. Aurousseau.

July 17, 1925.

Professor Sir Edgeworth David in the Chair.

Nine members and four visitors were present.

EXHIBITS:

1. By Mr. D. Scully, per Dr. C. Anderson—A fossil fish (unnamed) from Brookvale, New South Wales.

2. By Professor L. A. Cotton—A fossil plant (unnamed) from the Narrabeen Horizon.

3. By Rev. R. T. Wade—Photos of cross bedding in sandstone at Killara, New South Wales.

4. By Assistant-Professor W. R. Browne—(a) Tuff with apparent inclusions of finer Tuff or chert from Oberon Road, near Jenolan Caves, New South Wales, similar to that of Devonian age. (b) Ordovician phyllites showing bedding and schistosity.

5. By Mr. W. Poole—A number of specimens from the
   Mount Isa Field, Queensland, illustrating the ore
   deposit and geology of the field.

Mr. W. Poole gave a short account of his recent visit to
the Mount Isa Mines.

Dr. C. Anderson gave a lecturette on "The Geological
Aspect of his Presidential Address", pointing out that
there were two schools of thought on the question as to how
the flora and fauna came into Australia.   One favours
their introduction via the Antarctic Continent which at
one time connected Australia, New Zealand, South Africa
and South America.   The other school maintains that they
originated in the north or in the tropics and spread to the
South Lands by radiating paths, and that while their
ancestors have become extinct in the north they have
survived in the south.   Both schools of thought require
land bridges, and the geological problem is to discover
where these land bridges were located and at what time
they existed.   The present-day distribution of the fauna
and flora provides evidence which is conflicting and difficult
to determine.   The marsupials are represented in Australia
and the islands to the north as far as the Celebes and in
South America.   A few species are found in the South of
North America.   But in the Geological Record there is
evidence of marsupials existing in the north as early as
Cretaceous.   Marsupials of early Tertiary age have been
found in France and Germany.   If they came from the
north one would expect to find marsupial fossils in the late
Mesozoic or early Tertiary, but so far they have not been
found.   However, one can point to the paucity of fossil
marsupials in Australia, and it is a question of the relative
value of this negative evidence.

Mr. M. Aurousseau suggested that the Wegner
Hypothesis of drifting continents appeared to give the

most satisfactory explanation of the present-day distribution of fauna and flora.

Professor L. A. Cotton pointed out that according to the theory of isostacy where differences in density were fundamental, it is difficult to move continents as suggested by the Wegner hypothesis. The fauna and flora of Hawaii is extensive, and yet it was built up in deep water by volcanic action in late geological times.

Professor Sir Edgeworth David pointed out that the best preserved Jurassic flora in the Southern Hemisphere is that at Hope Bay, Graham Land. These forms resemble those of Australia more than the Australian forms do those of South Africa and British India. The oldest marsupial in Australia occurs in Tasmania in the Janjukian beds at Table Cape.

A strong argument is afforded by the polyprotodont type in New South Wales in Miocene. In the north there is no trace of marsupials in the Miocene deep leads. From south to north higher types are developed.

Dr. W. G. Woolnough and Rev. R. T. Wade also spoke.

August 21, 1925.

Dr. C. Anderson in the Chair.

Nine members and two visitors were present.

Mr. G. D. Osborne reported that at Seaham in the Maitland District, New South Wales, on July 18th, 1925, a Dedication Ceremony was held, when portion of a quarry containing varves showing contortions was formally reserved and dedicated to the interests of science.

Professor L. A. Cotton and Assistant-Professor W. R. Browne led a discussion of Dr. W. H. Bryan's presidential address to the Royal Society of Queensland—"Earth Movements of Queensland"

Mr. C. A. Sussmilch and Dr. Walkom also took part in the discussion.

September 18, 1925.

Dr. W. G. Woolnough in the Chair.

Four members were present.

EXHIBITS:

By Mr. T. Hodge Smith—(a) Crystallised albite from Upper Bingara, New South Wales. (b) Portion of the "Elsinora" meteorite from Elsinora Station, north west of Wanaaring, New South Wales.

A general discussion on the exhibits occupied the time of the meeting.

October 16, 1925.

Mr. E. C. Andrews in the Chair.

Ten members and five visitors were present.

EXHIBITS:

1. By Dr. W. G. Woolnough—(a) Phacolite deposited on a large crystal of calcite showing very regular periodicity of growth from Kyogle, New South Wales. (b) Zeolites in basalt from Kyogle, New South Wales. (c) Fossil worm tracks from Goulburn, New South Wales.

2. By Mr. C. A. Sussmilch—Crinoid Tribrachiocrinus.

3. By Mr. G. W. Card, from the Mining and Geological Museum—(a) Secondary galena from Junction North Mine, Broken Hill. (b) Rhodocrosite (perhaps intermixed with other carbonates) enveloped with pyrite and calcite, forming the infilling of a cavity, from Zinc Corporation Mine, Broken Hill, New South Wales. (c) Native Bismuth interlaminated with molybdenite, from Miss Saoh's Mine, Kingsgate, New South Wales.

4. By Rev. R. T. Wade—Fossil fish from Brookvale, New
   South Wales.

Dr. W. G. Woolnough gave a brief account of the
occurrence of zeolites at the Shire Quarry, Kyogle, New
South Wales.

Rev. R. T. Wade reported the presence of basalt dykes
at the Roseville Bridge and on the boundary of Gordon
and Killara (Sydney District) with a general W.N.W.
strike.

Mr. E. C. Andrews gave an account of a recent visit to
the north-western part of the State. The area considered
extends from the Queensland border for $3\frac{1}{2}°$ latitude south
and from the South Australian border 3° longitude east.
A number of residuals of Cretaceous rocks consisting of
conglomerates, grits, sandstones and shale were found to
be of different heights. The reason of this was that the
Cretaceous formed an anticline with an approximately
north and south axis. The residuals were all capped by
secondary quartzite (Tertiary). The underlying Poola-
mucco Series are much folded and faulted along the axis
of the anticline. This fault scarp is well seen at Mt.
Brown.

Professor L. A. Cotton, Dr. W. G. Woolnough, Messrs.
W. S. Dun and C. A. Sussmilch also spoke.

November, 16, 1925.

Mr. E. C. Andrews in the Chair.

Five members and four visitors were present.

EXHIBITS :

1. By Mr. G. W. Card, from the Mining and Geological
   Museum—A series of rocks illustrating the geology
   of the north-western part of the State.

2. By the Rev. R. T. Wade—A complete fossil insect and
   a number of fragments from Brookvale, New South
   Wales.

Assistant-Professor W. R. Browne addressed the Section on the "Age and Relation of the Metamorphic Rocks of the Monaro District, New South Wales". A belt of altered rocks has been traced from a little south of Cooma northward for about thirty miles, and has been found again about twenty miles further north at Tharwa in the Federal Capital Territory. The rocks consist mostly of slates, phyllites and micaschists, showing gradually increasing metamorphism and injected by gneissic granite rocks of two different ages. The metamorphism has been the result of the combined effect of pressure and igneous intrusion. The altered rocks, on the evidence of the graptolites in the slates, are believed to be of Ordovician age. Of the igneous intrusions the earlier was injected probably during the period of diastrophism that closed the Ordovician period, while the later, which shows differentiation-phases, due to pressure during crystallisation, may be of late Silurian age. The rock types in themselves and in their general relationships bear a remarkable resemblance to those of the Omeo District of Victoria.

December 18, 1925.

Mr. E. C. Andrews in the chair.

Eight members and one visitor present.

EXHIBITS:

By Assistant-Professor W. R. Browne—(a) A fracture-cleaved shale or slate of silurian age from Billilingra, near Bredbo; New South Wales. (b) Vertebraria-bearing shale from Ulan, about 25 miles north of Mudgee, New South Wales.

Mr. H. G. Raggatt gave an account of his recent trip to New Guinea, illustrated by lantern slides.

The lecture was discussed by Messrs. E. C. Andrews, L. L. Waterhouse, L. J. Jones and Assistant-Professor W. R. Browne.

SECTION OF AGRICULTURE.

SECTION of AGRICULTURE.

Annual Meeting, May 11, 1925.

Mr. E. A. Southee presided.

The election of officers resulted as follows:—*Chairman*—Principal E. A. Southee, O.B.E., M.A., B.Sc. Agr.; *Vice-Chairman*—Professor J. D. Stewart, B.V.Sc., M.R.C.V.S.; *Honorary Secretaries*—P. Hindmarsh, M.A., B.Sc. Agr.; R. J. Noble, Ph.D., B.Sc. Agr. *Committee*—A. A. Hamilton, M. Henry, D.S.O., B.V.Sc., M.R.C.V.S., A. E. Stephen, F.C.S., W. L. Waterhouse, M.C., B.Sc. Agr., D.I.C.

Principal Southee spoke upon "Genetic Research in Relation to Agriculture".

Meeting, July 13, 1925.

Professor J. D. Stewart in the Chair.

Mr. A. V. Robertson read a paper on "The Control of Milk Supply by Bacteriological Methods".

Mr. F. A. Perkins read a paper on "The Fruit Fly Problem of Stanthorpe".

Meeting, August 10, 1925.

Professor J. D. Stewart in the Chair.

Mr. H. J. Hynes read a paper on "Recent Work on Wheat Species Crosses".

Meeting, September 14, 1925.

Mr. E. A. Southee in the Chair.

A discussion upon "Animal Nutrition, with special reference to the hand feeding of cattle for beef production", was held in conjunction with the Veterinary Association of New South Wales.

Meeting, October 12, 1925.

Professor R. D. Watt in the Chair.

Mr. G. Wright spoke upon "Hydrogen-ion Concentration and its Application".

Meeting, November 16, 1925.

Mr. E. A. Southee in the Chair.

Mr. A. D. Ollé spoke upon "Some Observations on European Agriculture".

SECTION OF INDUSTRY.

SECTION OF INDUSTRY.

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Annual Meeting, May 20, 1925.

At the pre-lecture meeting of members, Mr. W. W. L'Estrange was elected Chairman for the coming session. Dr. R. Greig-Smith was re-elected Hon. Secretary.

Mr. W. W. L'Estrange in the Chair.

Mr. E. T. Fisk gave a lecture upon "Recent Advances in Wireless". After reminding members that the first demonstration of wireless telephony in Australia had been given in the Society's hall in August, 1919, the lecturer proceeded to describe some of the improvements that had lately been made. One of these was the receiving set without aerials. It was placed upon a table and while this was moved about the hall the broadcasting from Farmer's station was clearly audible. Another was the receipt of a message sent in Morse upon a short wave length from the S.S. "Niagara," then a day's run from Honolulu.

At present thirty per cent. of the telegraphic traffic is carried from England by wireless in one-fifth to one-twentieth of a second; it is sent by typewriter and received on the tape.

Directional transmission of short waves has effected a great saving of power, one-fortieth of the old power with a six-fold capacity for transmission at twenty-five per cent. of the old cost.

The care necessary for the adjustment of Franklin's reflector for beam wireless was emphasised and it was pointed out that the Canadian reflector can differentiate between Sydney and Melbourne. By the use of directional finders, a ship in a fog can determine its exact position.

June 17, 1925.

Mr. W. W. L'Estrange in the Chair.

Mr. S. E. Sibley exhibited a small model of the Streamline Filter, which consists of a great number of sheets of non-porous paper tightly pressed in a frame. The fluids to be filtered are forced between the surfaces instead of through the paper. Mr. Hyland demonstrated its action in clarifying cloudy vinegar and in separating an emulsion of benzene and sodium oleate.

Mr. R. Grant exhibited a specimen of Dreyer's Antigen and described its preparation from *Bac. tuberculosis.*

Mr. H. V. Bettley-Cooke exhibited specimens of several curious chemical substances.

July 15, 1925.

Mr. W. W. L'Estrange in the Chair.

Mr. A. Dickinson, of S. T. Leigh and Co., gave an address upon "Photo-mechanical Printing Processes," and exhibited many prints in illustration of the processes. The old collotype process has again come into favour with the employment of thick glass plates for the foundation. The technical details regarding the cleaning of the plates, the preparation of the albumen substratum, the bichromate-gelatin film, the sensitising of the plate by baking, the printing and the development of the negative, were given in extenso.

August 19, 1925.

Mr. W. W. L'Estrange in the Chair.

Mr. Van der Velden, on behalf of the Kodak (Australasia) Pty. Ltd., exhibited the new Cine-Kodak, a compact apparatus for taking small-sized cinema films, and the Kodascope, a lantern for projecting the ribbon films. Several scientific and other films were projected to the interest and entertainment of the members.

September 8, 1925.

Visit to Parke, Davis and Co.'s laboratories.

At the invitation of the Acting Assistant-Manager, a visit was made to the laboratories of Messrs. Parke, Davis and Co. at Rosebery, where the preparation of the firm's products was seen. Many processes had been specially made ready for the occasion and the visiting members enjoyed the firm's kindness and hospitality.

September 16, 1925.

Mr. W. W. L'Estrange in the Chair.

Mr. H. V. Bettley-Cooke gave an address upon "Essential Oils," during which he exhibited specimens of a wide range of oils and described their origin, preparation, chief components and occasional adulterants.

October 13, 1925.

Visit to the White Bay Power House.

Through the kindness of Mr. W. H. Myers, B.E., etc., Chief Electrical Engineer for Railways and Tramways, the members visited the White Bay Power House and were conducted over the works by Messrs. Hutchinson, Ferguson, Haigh and Stafford.

November 10, 1925.

Visit to the Tramway Work-shops.

Also by the courtesy of Mr. W. H. Myers, a visit was paid to the Tramway Work-shops at Randwick, when the members had the opportunity of seeing the physical laboratory, where metals, lamps, insulators and apparatus generally were being tested. Special tests had been prepared and were explained by Mr. E. E. Lacy and his staff. Subsequently the visitors were shown over the general shops by Messrs. Barnes and Edwards.

SECTION OF PHYSICAL SCIENCE.

PHYSICAL SCIENCE.

Professor O. U. Vonwiller in the Chair.

The following were elected Officers and Committee for the Session 1925-6:—*Chairman*—Professor O. U. Vonwiller, B.Sc. *Secretaries*—Assoc. Professor V. A. Bailey, M.A., Dr. Phil., and Mr. J. J. Richardson, A.M.I.E.E. *Committee*—Rev. E. F. Pigot, S.J., B.A., M.B., Professor J. P. Madsen, D.Sc., B.E., A. B. Ranclaud, B.Sc., B.E., and E. M. Wellish, M.A.

A lecture on the "Behaviour of Electrons in Gases" was delivered by Prof. V. A. Bailey. An outline was given of work done by J. S. Townsend, H. T. Tizard and the speaker on the determination of the mean energy of agitation and the mean drift velocity of electrons moving in a uniform field in different gases at different pressures. These two quantities enable the mean free path of the electrons and the mean fractional loss of energy at a collision to be determined for different gases.

The results obtained are of great interest, especially those for Argon, where it was found that the mean free path increased by a factor of twenty when the mean velocity of agitation decreased by a factor of five. It was also found that within the range of velocities $10^7 - 2 \times 10^8$ cms./sec. none of the electrons attached themselves to the molecules of H_2, N_2, CO_2, CO, He, Ne and A. The numbers for the mean fractional losses of

energy at collisions showed that with the three inert
gases the collisions were closely resembling those for
perfectly elastic bodies, but that with the other gases
internal energy was taken up by the molecules from the
colliding electrons.

Meeting, June 25, 1925.

Professor O. U. Vonwiller in the Chair.

The business consisted of two short lectures.

The first, entitled "Notes on some remarkable Seismo-
grams from Riverview," was delivered by the Rev. Dr.
E. F. Pigot. The lecture was fully illustrated by actual
seismograms obtained by ' Father Pigot at Riverview.
Among these were the Kurrajong earthquake, the careful
analysis of which by Professor Cotton has been published
in the Journal of the Society, and the earthquakes with
epicentres at Bundaberg, Queensland, New Hebrides,
Sumatra, Ceylon and the Philippine Islands. The charac-
teristics of the various records were clearly explained,
and the method of azimuth determination of epicentre
originated by Prince Galitzin fully described. The
probable cause of earthquakes was given as a sudden
break or joggling along a fault plane.

Professor V. A. Bailey delivered the second lecture,
which was entitled "On Feats of Mental Arithmetic."
After reviewing many cases of abnormal capacity for
manipulating large numbers mentally, the lecturer
described and illustrated by examples a method devised
by himself for the rapid determination of the products
of numbers consisting of several figures.

The method may be readily followed from the following
example :—

<div align="center">2379 × 5478.</div>

Position.	Mental Process.	Digits obtained.
2379 　　8745	$8 \times 9 = 72$	2
2379 　8745	$(7 \times 9) + (8 \times 7) + 7 = 126$	62
2379 　8745	$(4 \times 9) + (7 \times 7) + (8 \times 3) + 12 = 121$	162
2379 8745	$(5 \times 9) + (4 \times 7) + (7 \times 3)$ 　　　　　　　　$+ (8 \times 2) + 12 = 122$	2162
2379 8745	$(5 \times 7) + (4 \times 3) + (7 \times 2) + 12 = 73$	32162
2379 8745	$(5 \times 3) + (4 \times 2) + 7 = 30$	032162
2379 8745	$(5 \times 2) + 3 = 13$	13032162

Answer 13032162.

The steps which are given above are performed mentally and the answer is written down direct.

The method may be extended to include squares, square roots and division.

<div align="center">*Meeting, July 16, 1925.*</div>

Professor O. U. Vonwiller in the Chair.

Ten members were present.

A lecture on the ''Attachment of Electrons to Molecules'' was delivered by Professor V. A. Bailey. The lecturer described in detail and illustrated by drawings on the board the apparatus he employs to determine the attachment of electrons to molecules of a gas. The gas he used was atmospheric air and precautions were taken to free it entirely from moisture.

The results of previous experiments carried out by Professor Bailey indicated that within the limiting conditions of the experiments electrons do not attach themselves

to H_2, N_2, CO_2, CO and certain other gases.   Recent
experiments carried out by H. L. Brose at Oxford indicate
that O_2 may now be included with these gases. Professor
Bailey's results with air, however, indicate that molecular
ions are formed, but his work is not sufficiently far
advanced for him to state the nature of these ions.

Meeting, August 20, 1925.

Professor O. U. Vonwiller in the Chair.

Eleven members were present.

The Chairman read a paper entitled "Notes on Recent
Work on Radiation."

Bohr's theory of atoms and the emission of light was
outlined, together with some of the developments of his
work.   Mention was made of some of the attempts to
reconcile optical phenomena, such as dispersion and inter-
ference with the quantum theory. In particular, attention
was drawn to the view recently suggested as possible by
Bohr, Kramers and Slater that excited atoms actually
radiate and absorb while in a stationary state, the emission
consisting of radiations corresponding with each of the
transitions possible from that state, and the intensity of
each radiation being proportional to the product of the
quantum of energy associated with it and the probability
of the corresponding transition so that there is, with a
large number of atoms, a statistical balance between the
energy emitted and the change of energy due to the
transitions. The view was shown to remove some difficulties
but introduces assumptions not easily accepted. It may,
however, be a step towards a more complete solution of
the problem.

Meeting, September 17, 1925.

Professor O. U. Vonwiller in the Chair.

Twelve members were present.

Mr. E. M. Wellish read a paper on "Some Aspects of Electromagnetic Theory."

In illustration of Maxwell's idea of electric displacement, he employed the latter's now classical equations to determine the displacement current densities in the two cases:—

(i) uniform transverse motion of an electrified line or cylinder and

(ii) a uniformly moving point charge.

Both these cases were illustrated by diagrams, showing the lines of displacement.

General expressions were given for the electric and magnetic current densities due to the (practically) unrestricted motion of a point-charge, these being of particularly compact forms.

The special case of a linear harmonic oscillator was then considered; and resulted in the unexpected and interesting conclusion that the waves produced by the oscillator contain "overtones".

Meeting, October 15, 1925.

Professor O. U. Vonwiller in the Chair.

Mr. S. Radcliff read a paper on "Is Radio-activity a Universal Property?"

He drew attention to a number of significant quantitative and qualitative relations in the occurrence together of similar elements resembling those which exist for the radioactive elements, and stated that on this account he was engaged in an investigation of the possibility of radioactivity occurring in elements outside the present recognised radioactive ones.

One fact quoted in support of this possibility was the observation by the present Lord Rayleigh that the helium

content of beryl is about 500 times greater than that
proper to its content of known radioactive matter.

An outline was given of the proposed method of
investigation, and an interesting discussion followed.

Meeting, November 19, 1925.

Professor O. U. Vonwiller in the Chair.

Reports on current scientific literature were given as
follows:—

The Chairman on "The Isotope Effect in Band-Spectra".

The theory, given by Sommerfield and developed by
Kratzer and others, that each line in the band spectrum
of a diatomic molecule is due to the simultaneous occurrence
of quantum changes of three types, electronic, molecular
vibrational and molecular rotational, was outlined.   In
the expression obtained for the frequencies of the lines,
due to the molecular quantum changes occur mass factors
of the form $\mu^{-\alpha}$ where $1/\mu = 1/M_1 + 1/M_2$, M_1 and M_2
being the masses of the nuclei.   In the case of isotopes
M_1 may have values differing by several units, giving
values of μ differing by quite an appreciable amount, with
a consequent measurable separation of lines in the two
spectra very much greater than the corresponding isotope
effect in line spectra, where we are concerned with a μ
given by $1/\mu = 1/m + 1/M$, m and M being the masses
of an electron and a nucleus respectively.

The isotopic effect on the origins of band systems and
of bands, and on the lines in a band was discussed, and
an account given of Mulliken's recent confirmatory
observations on the spectra of B O and Cu I.

Professor V. A. Bailey outlined a paper by H. Daeke
published in the Philosophical Magazine of September,

1925, and entitled "A Mathematical Statistical Investigation concerning Sub-electrons".

The subject of investigation is the series of values, obtained by E. Radel and M. König, of the charges on mercury particles (of diameters $< 10^{-5}$ cm.) which substantially fall short of the value $e=4.77\times10^{-10}$ e.s.u. The author considers the probability that the 24 values of König be integral multiples of a fundamental charge (e.g. 0.50×10^{-10}), employing a criterion for integers which R. von Mises has developed by means of the cyclical theory of errors.

He concludes that the assumption, that the sub-electrons may be represented by the form me/n, where m and n are integers which are not large and m $<$ n, has a greater probability than *any other assumption*.

He then suggests that for particles of small radius ($< 10^{-5}$ cm.) a division of the electron into n equal parts may take place, of which m may occur united.

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